Electrical Level 4

Fire Alarm Systems 26405-14

Objectives

When trainees have completed this lesson, they should be able to do the following:

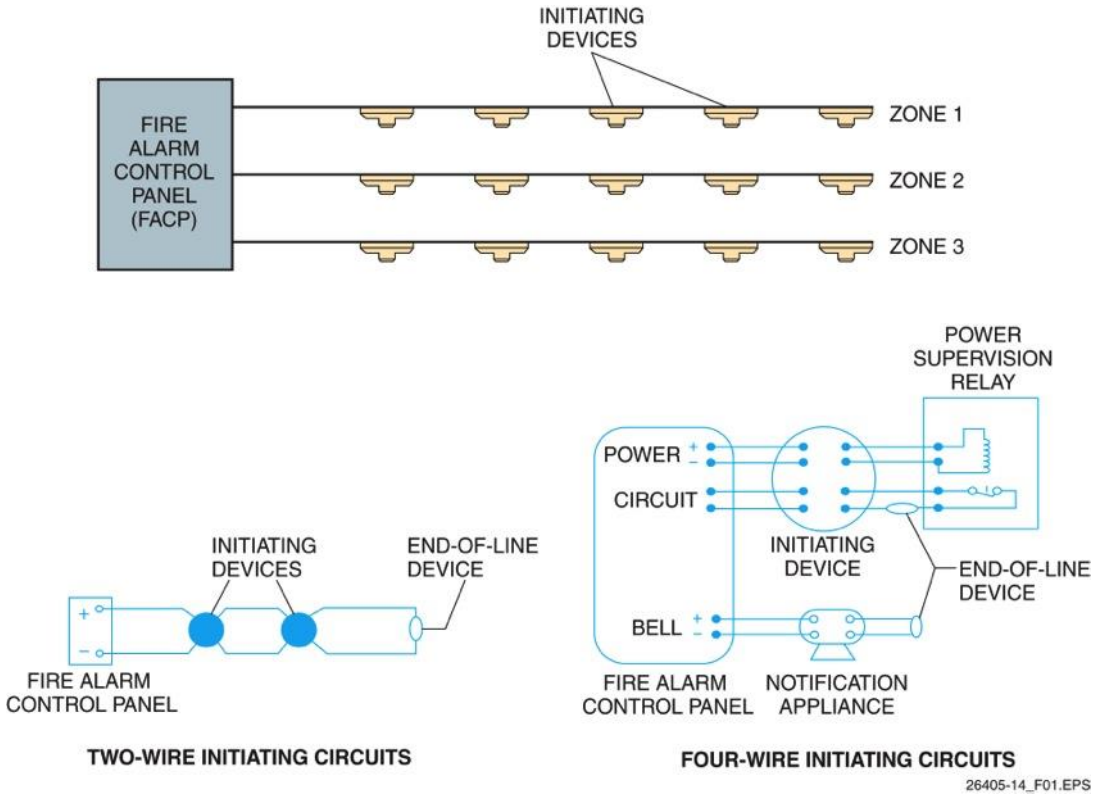
1. Define the unique terminology associated with fire alarm systems.
2. Describe the relationship between fire alarm systems and life safety.
3. Explain the role that various codes and standards play in both commercial and residential fire alarm applications.
4. Describe the characteristics and functions of various fire alarm system components.
5. Identify the different types of circuitry that connect fire alarm system components.
6. Describe the theory behind conventional, addressable, and analog fire alarm systems and explain how these systems function.

Performance Task

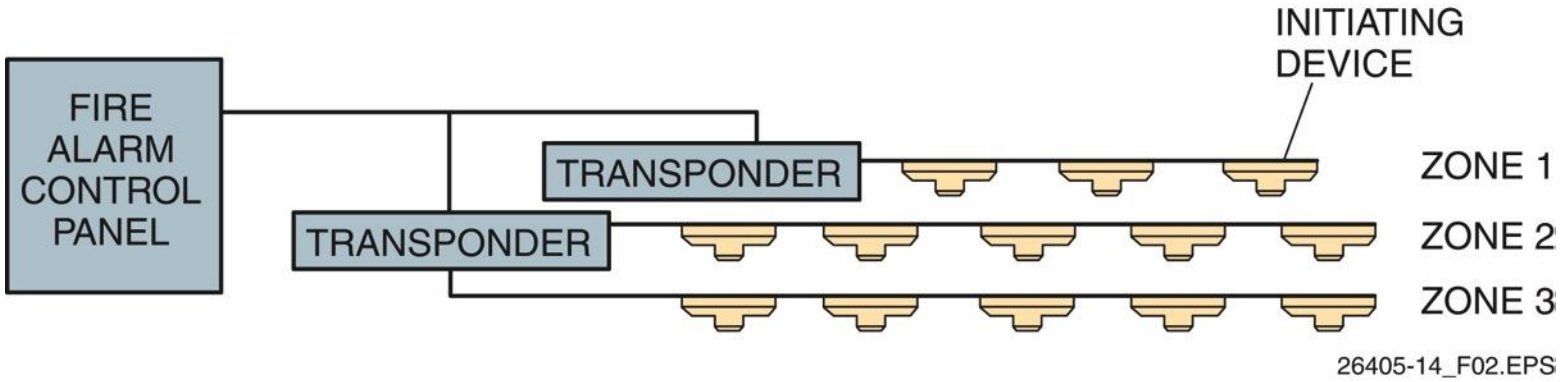
Connect selected fire alarm system(s).

Introduction; Codes and Standards; Fire Alarm Systems Overview; Fire Alarm System Equipment

- Automatic fire alarm systems provide fire protection for life safety, property protection, or mission protection.
- Fire alarm systems are categorized by the communication method between the detectors and fire alarm control panel (FACP). A conventional hardwired system is the simplest type.



Typical Multiplex System



- Multiplex systems use zones for detection, but allow multiple signals from different sources over the same line.
- Because each signal can be uniquely identified, multiplex systems require less wiring and control equipment.

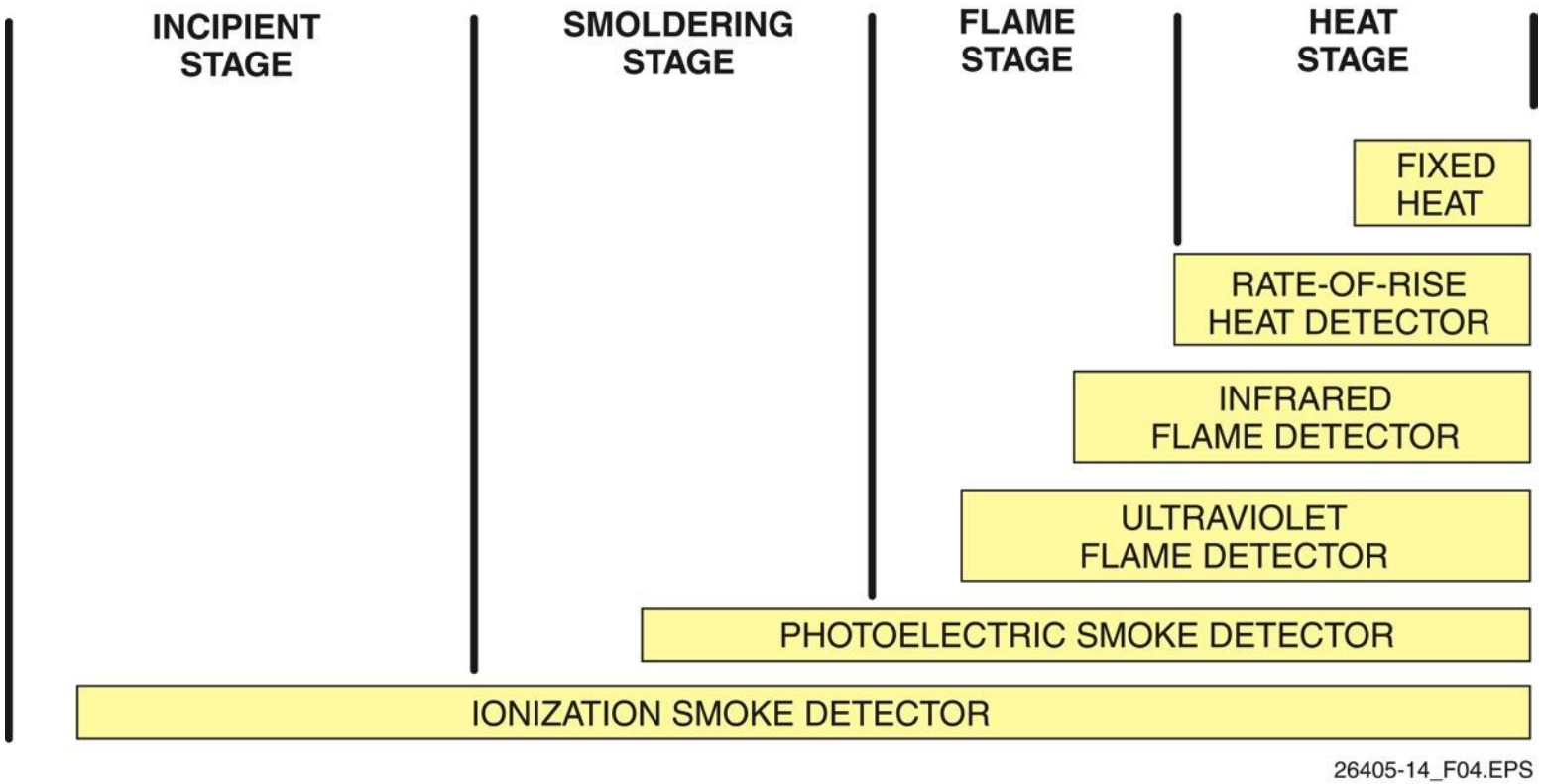
Next Session…

Typical Addressable or Analog Addressable System

- Addressable systems identify the location of each initiating device by assigning a unique address to each device on the signaling line circuit (SLC).
- The fire alarm control panel (FACP) continually polls each device status (normal, trouble, alarm). Some addressable systems can also provide details such as the smoke level.

Fire Alarm Initiating Devices

Fire Alarm Initiating Devices



Typical Commercial Automatic Sensors

- Commercial detectors differ from residential detectors in that they are typically wired in parallel and connected to an FACP.
- Commercial fire alarm systems are normally divided into different building areas or zones.

IONIZATION OR PHOTOELECTRIC SMOKE DETECTOR

PHOTOELECTRIC SMOKE DETECTOR WITH FIXED-TEMPERATURE HEAT SENSOR

RATE-OF-RISE HEAT DETECTOR WITH FIXED-TEMPERATURE HEAT SENSOR

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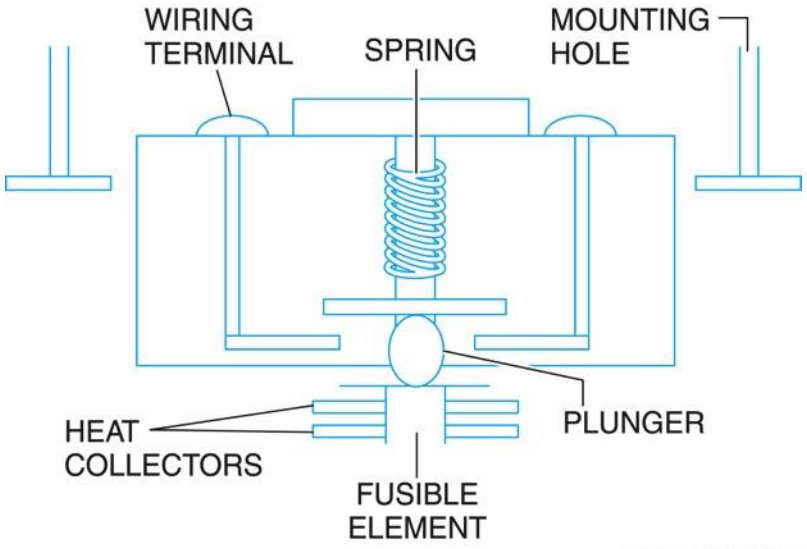
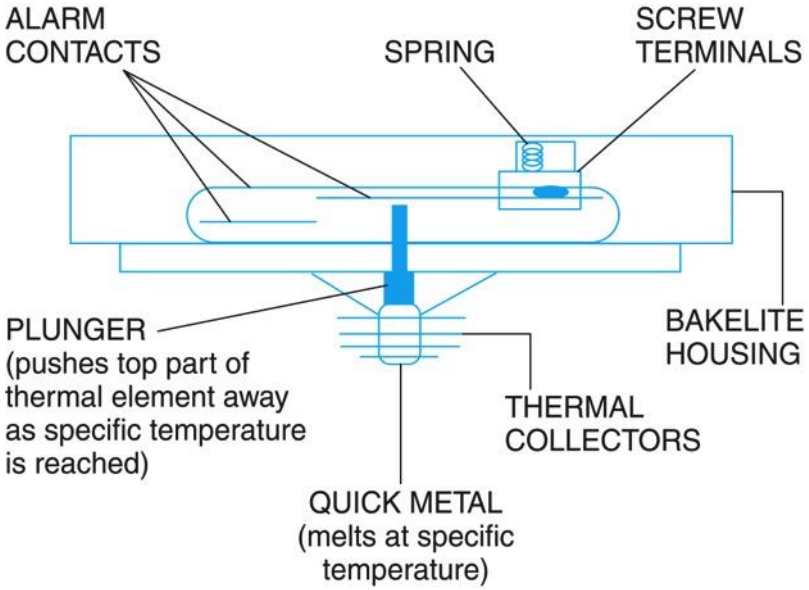
Fusible Link Detector

- There are two main types of heat detectors: rate-of-rise detectors, which trigger when sensing a temperature increase of 15 degrees/minute; and fixed-temperature detectors, which trigger at a set temperature.
- Fixed-temperature temperatures are available as fusible link, quick metal, and bimetallic types.

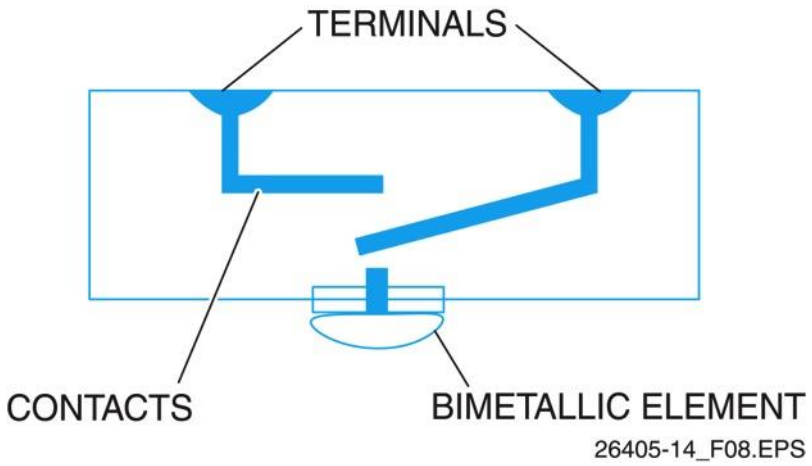


Quick Metal Detector

- Quick metal detectors use a low-melting point metal to trigger a spring actuator that closes the switch contacts.
- As with fusible link detectors, the heat collector in a quick metal detector must be replaced to reset the device.



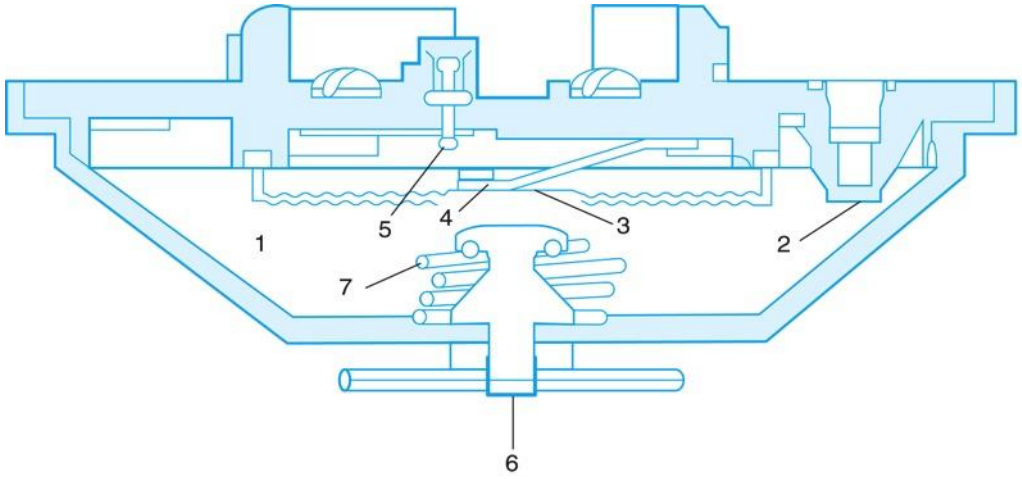
Bimetallic Detector



- Bimetallic heat detectors use a bimetal element to close the switch contacts.
- Bimetallic heat detectors offer an advantage in that the heat detector is self restoring and does not require replacement in order to reset the device.

Rate-of-Rise with Fusible Link Detector

- Combination heat detectors use a rate-of-rise detector and a heat detector to respond to a rapid temperature increase even if the device does not reach a preset temperature.
- In the combination detector shown here, the center (fusible link) section must be replaced if the temperature exceeds the preset level.



1. Chamber
2. Vent
3. Diaphragm
4. Contact
5. Contact Screw
6. Fusible Alloy
7. Spring

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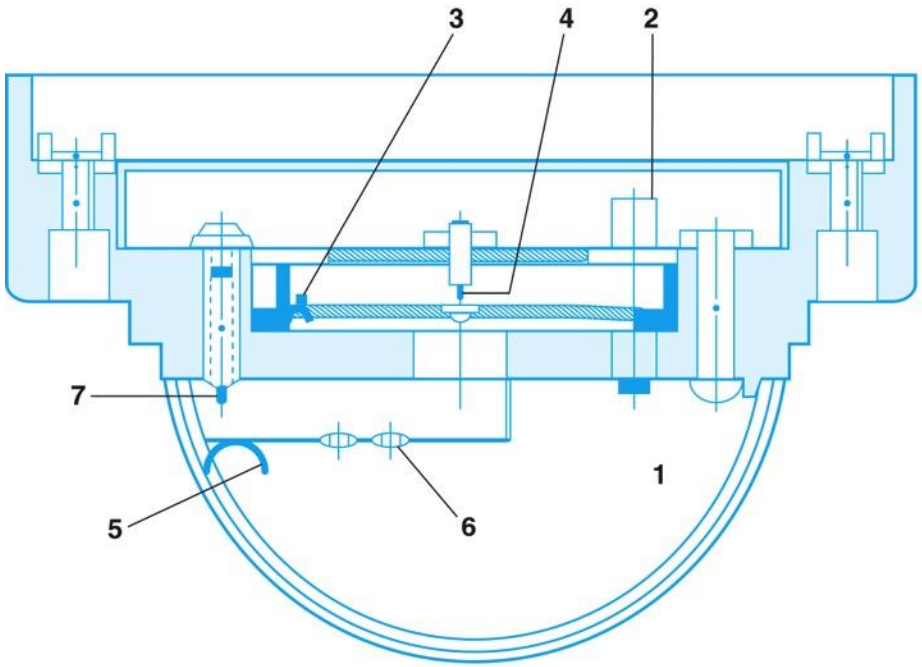
Rate-of-Rise with Bimetallic Detector

A rate-of-rise/bimetallic detector offers an advantage in that the bimetallic element does not have to be replaced and resets itself when the temperature returns to normal.



1. Air Chamber
2. Breather Valve
3. Diaphragm Assembly
4. Rate-of-Rise Contact
5. Bimetal Fixed-Temperature Element
6. Contact Spring
7. Fixed-Temperature Contact

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Heat Detector Temperature Ratings

Temperature Classification	Temperature Rating Range	Maximum Ceiling Temperature	Color Code
Low	100°F–134°F	80°F	No color
Ordinary	135°F–174°F	100°F	No color
Intermediate	175°F–249°F	150°F	White
High	250°F–324°F	225°F	Blue
Extra high	325°F–399°F	300°F	Red
Very extra high	400°F–499°F	375°F	Green
Ultra high	500°F–575°F	475°F	Orange

Typical Photoelectric Smoke Detector

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Photoelectric smoke detectors sense the presence of smoke and can be combined with an ionization detector for residential use and a heat detector for commercial use.

Typical Ionization Smoke Detector

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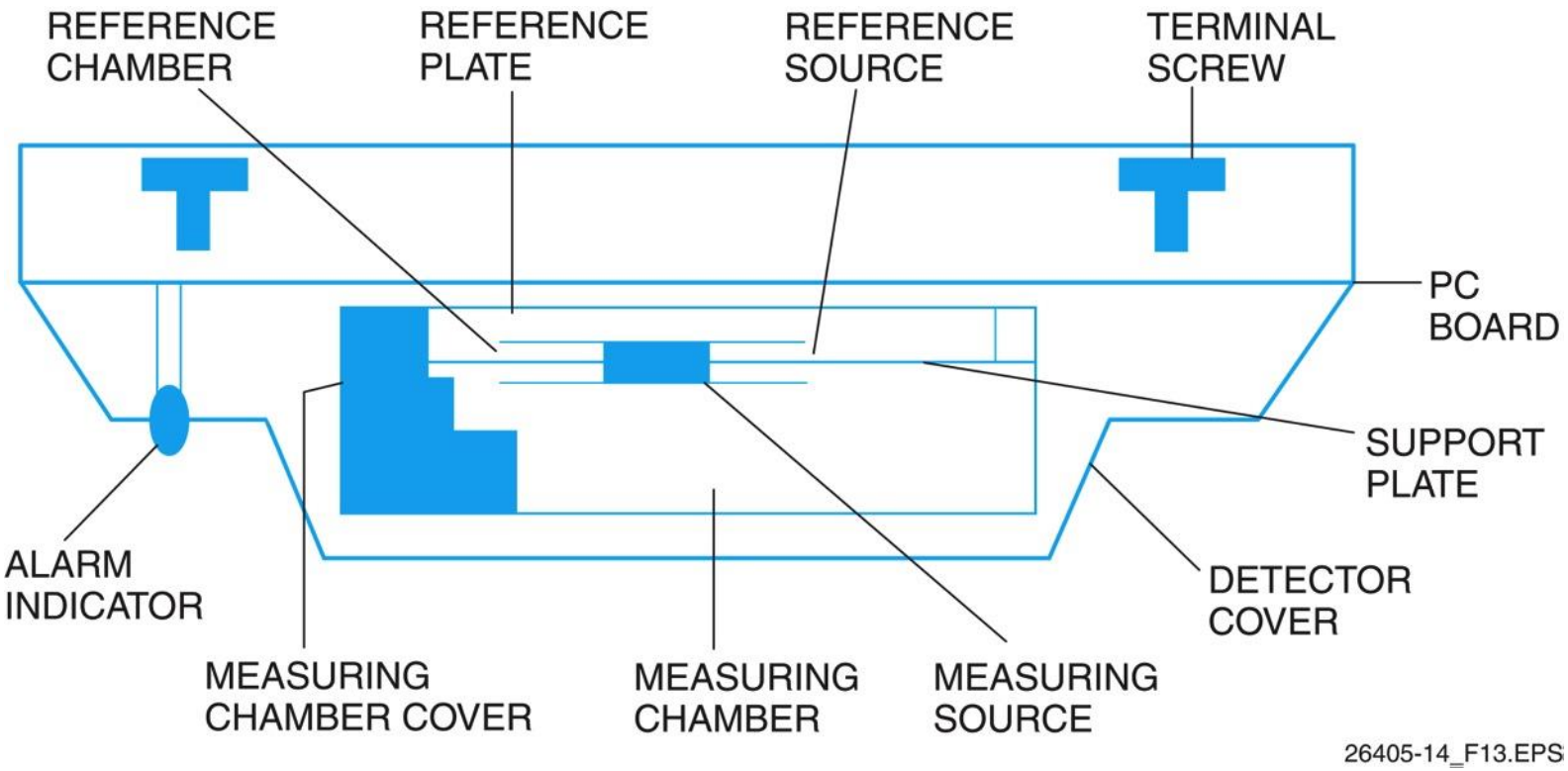
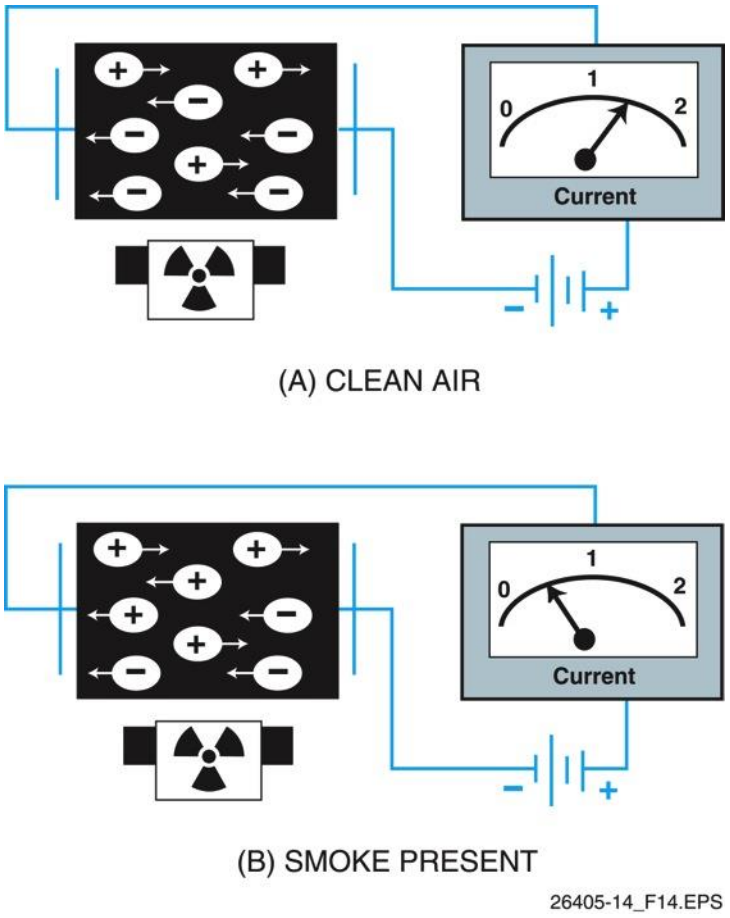
Ionization smoke detectors sense the presence of combustible gases and can be combined with a photoelectric detector for residential use and a heat detector for commercial use.

Ionization Detector



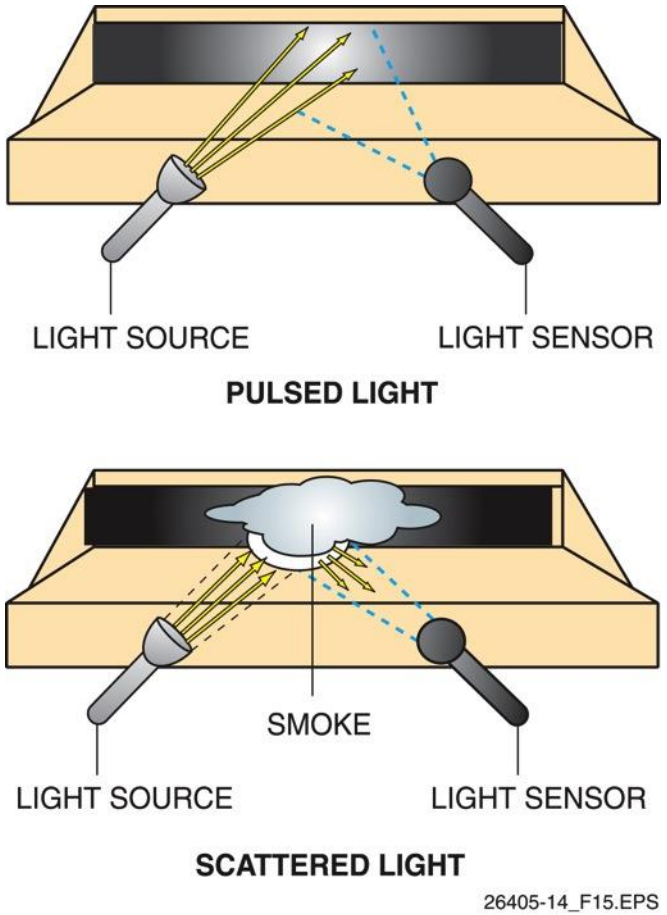
Ionization Action



- An ionization smoke detector detects changes in the electrical conductivity of air due to the presence of combustible gases.
- A radioactive material is used to ionize the air, allowing it to conduct current. Smoke particles interfere with conduction and activate the alarm circuit.

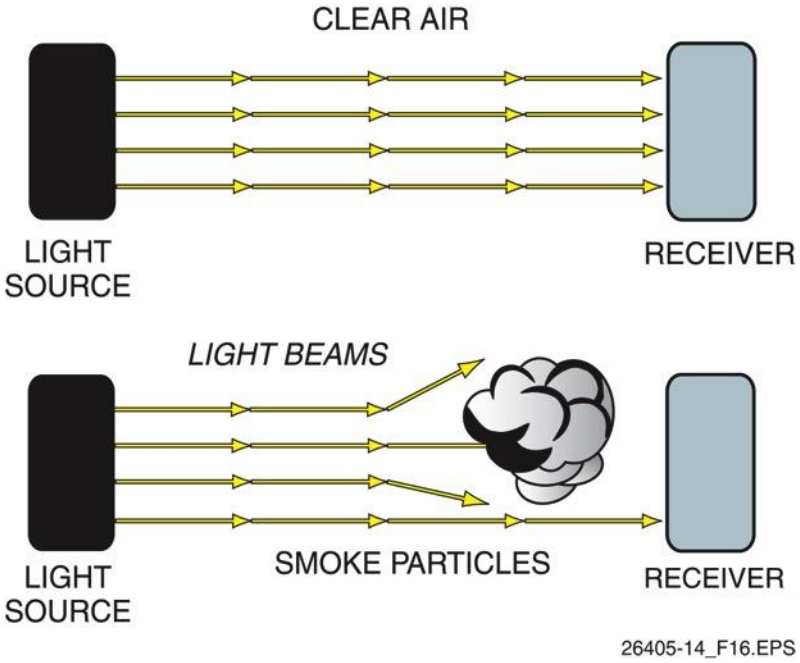
Light-Scattering Detector Operation

- There are two types of photoelectric detectors: light-scattering detectors and beam detectors.
- In a light-scattering detector, the light source is set up so that light will not fall on the sensor under normal conditions. The presence of smoke scatters the light, which is then picked up by the sensor to activate the alarm.

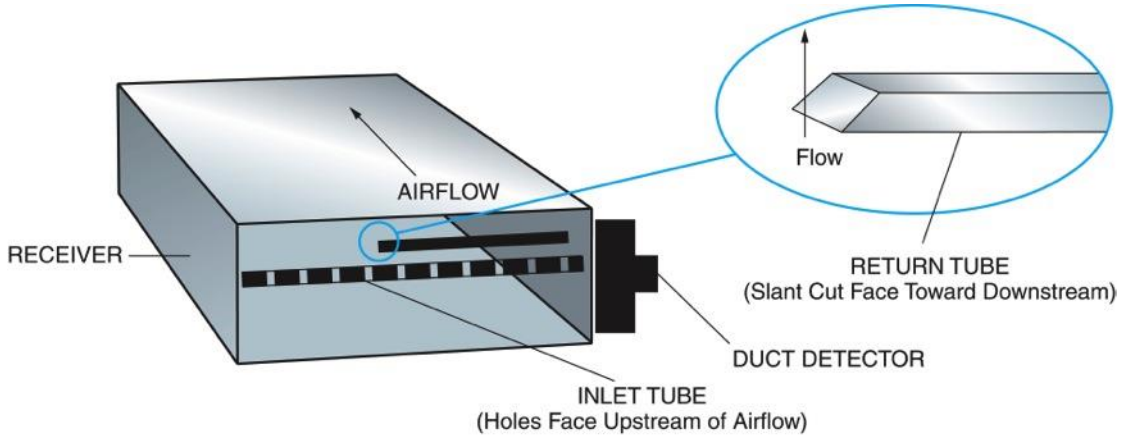


Light Obscuration Principle

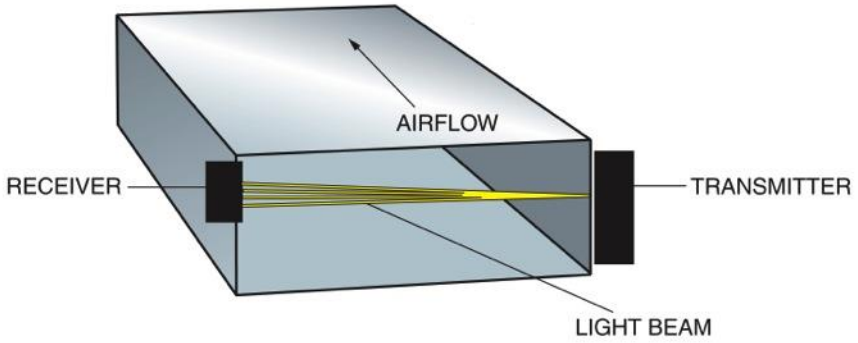
- Projected-beam detectors are set up so that light falls on the sensor under normal conditions. The presence of smoke reduces the amount of light reaching the sensor, activating the alarm.
- Projected-beam detectors are used in applications with high ceilings such as open-bay warehouses, churches, and other large areas.



Typical Duct Detector Installations



SAMPLING TUBE STYLE



PROJECTED LIGHT BEAM STYLE

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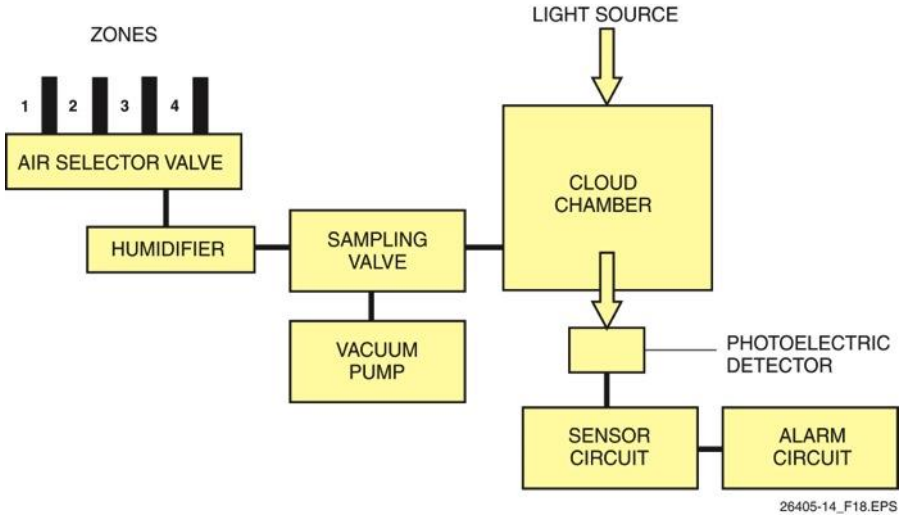
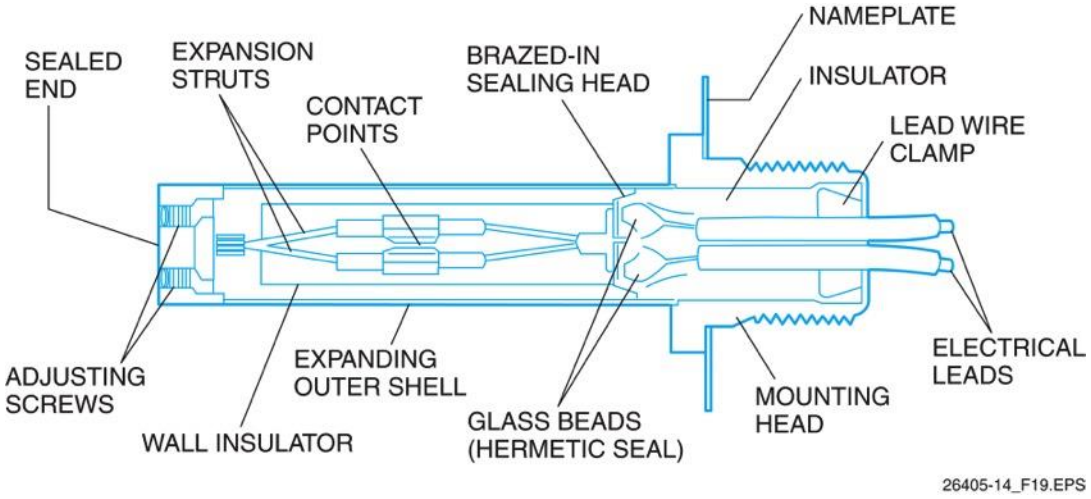
Cloud Chamber Smoke Detector

- Cloud chamber smoke detectors use sampling tubes to draw air from several zones into a vacuum tube where the reduced pressure causes water droplets to form around any smoke particles.
- A light beam passed through the sampling tube is interrupted by the presence of particles, activating the alarm.



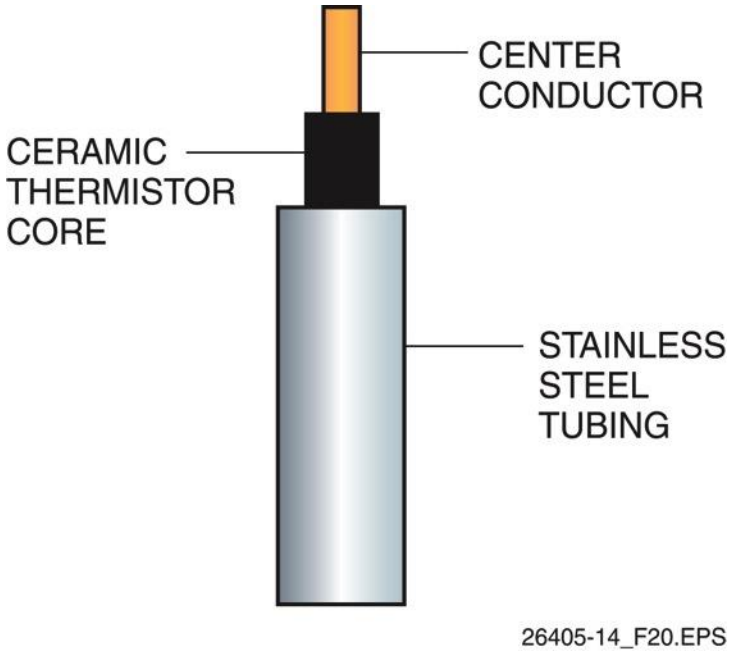
Rate Compensation Detector

- A rate compensation detector responds when the temperature of the surrounding air reaches a preset level or if it rises quickly over a short period.
- These detectors are self-restoring, offer precise control, and are used in applications where thermal lag must be minimized.



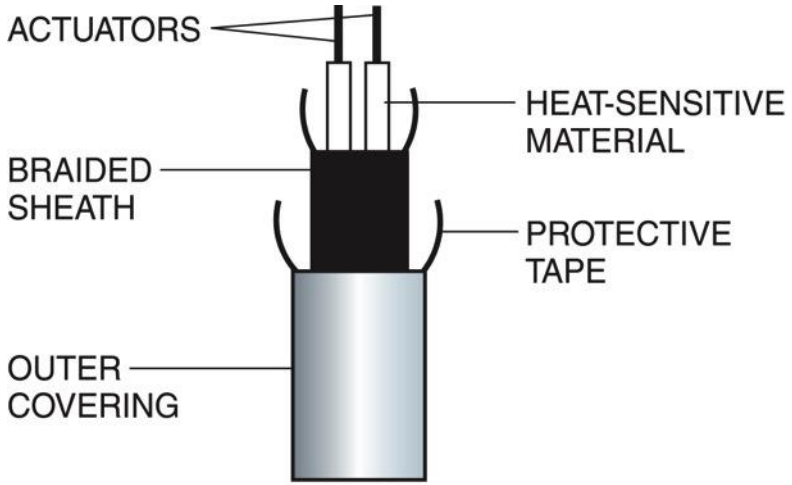
Restorable Semiconductor Line-Type Heat Detector

- Semiconductor line-type heat detectors use a semiconductor thermistor material to respond to temperature changes.
- As the temperature rises, it allows more current to flow and initiates the alarm. The alarm resets when the temperature decreases below the threshold temperature.



Non-Restorable Fusible Line-Type Heat Detector

- Fusible line-type heat detectors use two pieces of steel wire separated by insulation. When the temperature of the surrounding air reaches a preset level, the insulation melts and the two wires come into contact, initiating an alarm.
- The melted and fused section must be replaced in order to reset the alarm.



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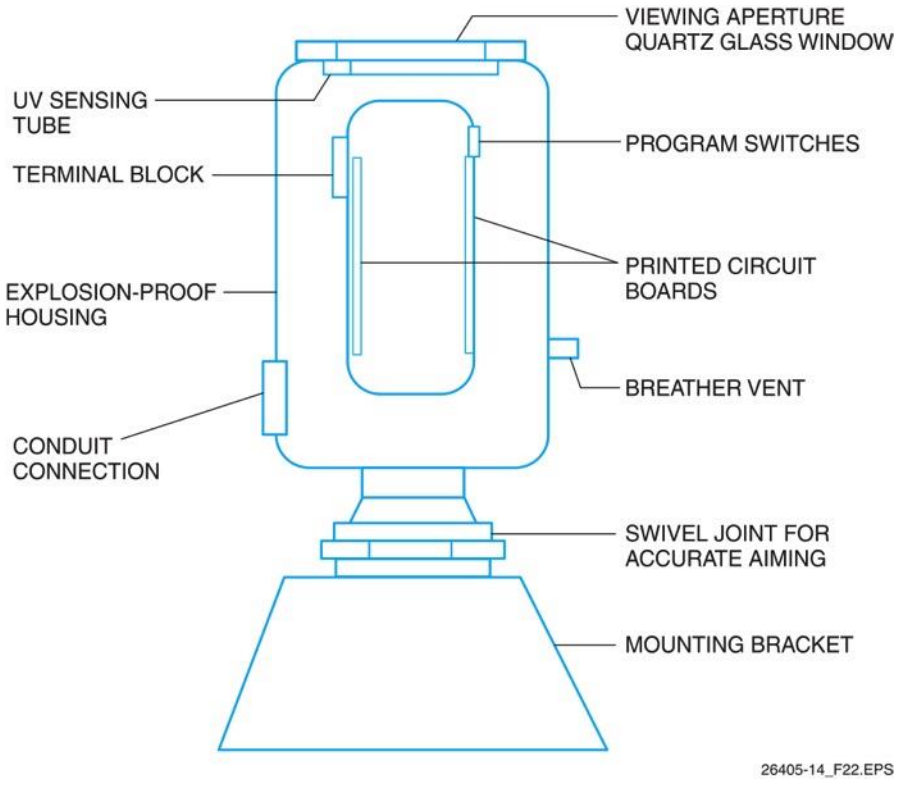
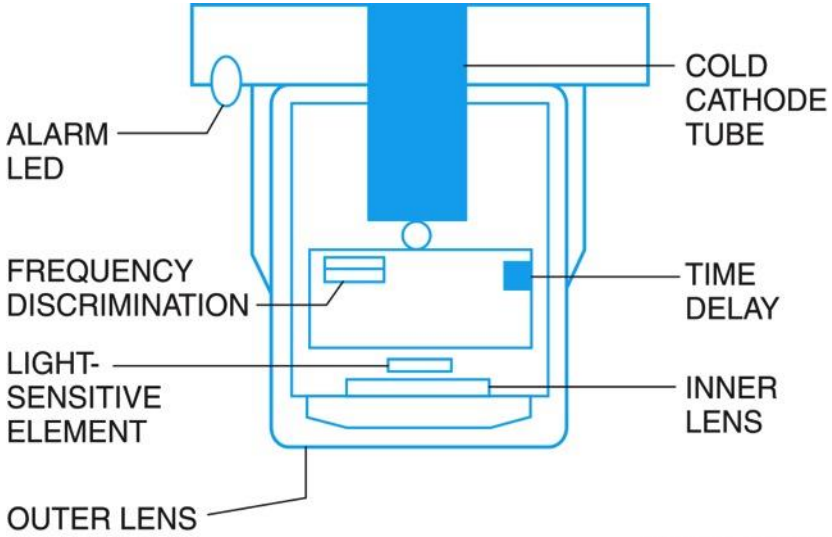
UV Flame Detector (Top View)

- Ultraviolet (UV) flame detectors use a solid-state sensing element of silicon carbide, aluminum nitrate, or a gas-filled tube to sense the presence of a flame.
- The UV radiation of a flame causes the gas in the element to ionize and conduct a current, activating the alarm.



IR Flame Detector (Top View)

- Infrared (IR) flame detectors use a lens to focus the incoming energy on a light-sensitive component that activates the alarm when the IR exceeds a preset level.
- These devices are used indoors and contain a filter or other system to prevent nuisance trips due to sunlight.



Typical Pull Stations

Manual pull stations are located in the normal path of exit from a building to provide an immediate warning in the event of a fire.

SINGLE-ACTION PULL STATION

GLASS-BREAK COVER FOR PULL STATION

DOUBLE-ACTION PULL STATION

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Key-Operated Pull Station

Key-operated pull stations are used where staff presence is continuous and occupant use is undesirable, such as in correctional or mental health facilities.

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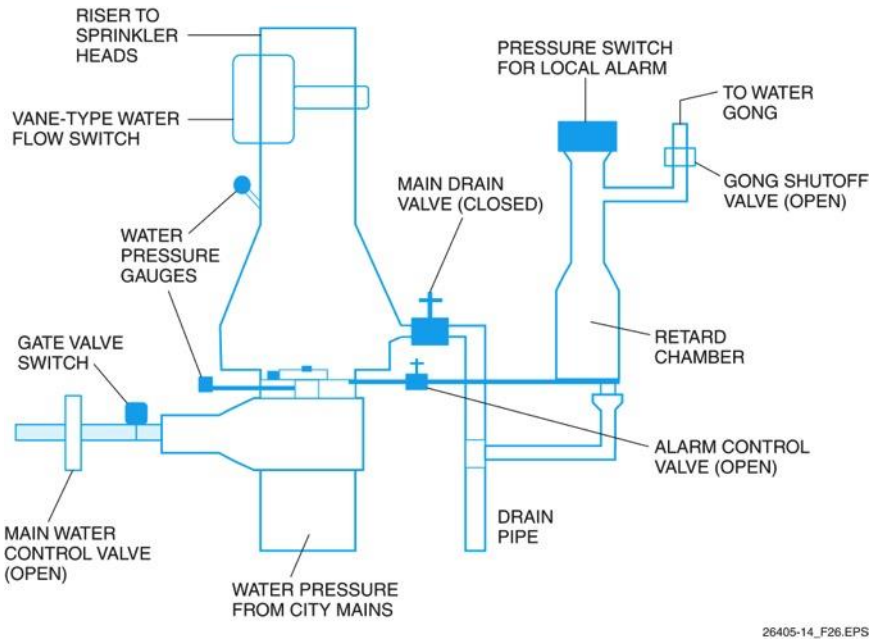
Wet Sprinkler System

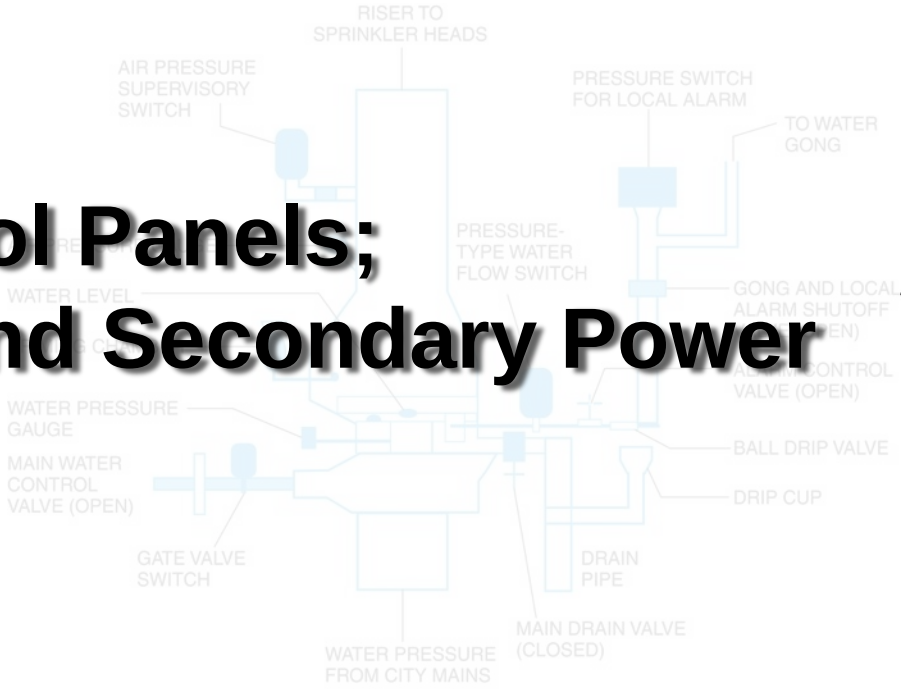
- A wet sprinkler system consists of permanently piped water under pressure and heat-actuated sprinkler heads.
- The sprinkler heads activate individually to control a fire. They also actuate a fire alarm.



Next Session…

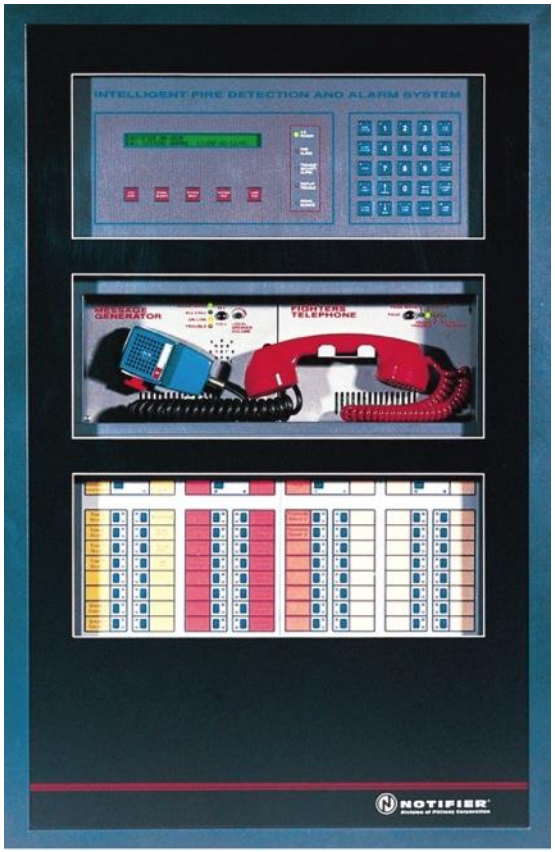
Dry Sprinkler System

- A dry sprinkler system consists of a piping system containing air under pressure and heat-actuated sprinkler heads.
- The sprinkler heads actuated during a fire open the water valves and also actuate a fire alarm.
- Dry systems are used in areas subject to freezing. If a dry system fills with water, it must be drained.



Control Panels;
FACP Primary and Secondary Power

Control Panels; FACP Primary and Secondary Power



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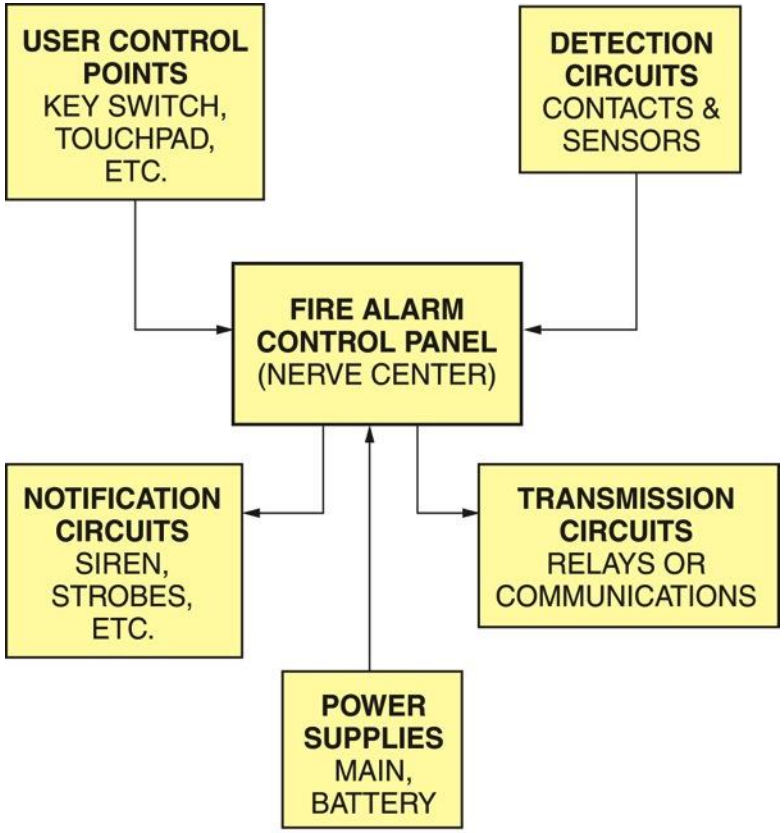
This addressable control panel has a voice command system that can be used for automatic evacuation messages, as well as communication with a central station through a telephone network and a firefighter paging system.

Fire Alarm Control Panel Inputs and Outputs



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Alphanumeric Keypad and Display

- User control points allow the user to turn the system on and off, monitor the system, and reset alarm or trouble indicators.
- Common user control points include alphanumeric or LED keypads, touch screens, and telephone/computer controls.

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Notification Appliances

- Occupant notification is the most important life safety function of a fire alarm system. There are two types of notification devices: audible and visual.
- Most interior visual notification devices use clear strobe lights. Where two or more lights are visible from the same location, they must be synchronized to avoid random flashing.

Typical Bell with a Strobe Light

- Audible signals used for fire alarms must be easily distinguishable from other alarms in a work area (e.g., process control or backup alarms).
- *NFPA 72®* specifies a standard signal known as Temporal-3 for most fire alarm signals.

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Typical Horn with a Strobe Light

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Voice Evacuation System

- Voice evacuation systems provide occupant instructions during an emergency.
- These systems can be used in conjunction with an FACP or as a standalone system with a built-in power supply and battery backup.

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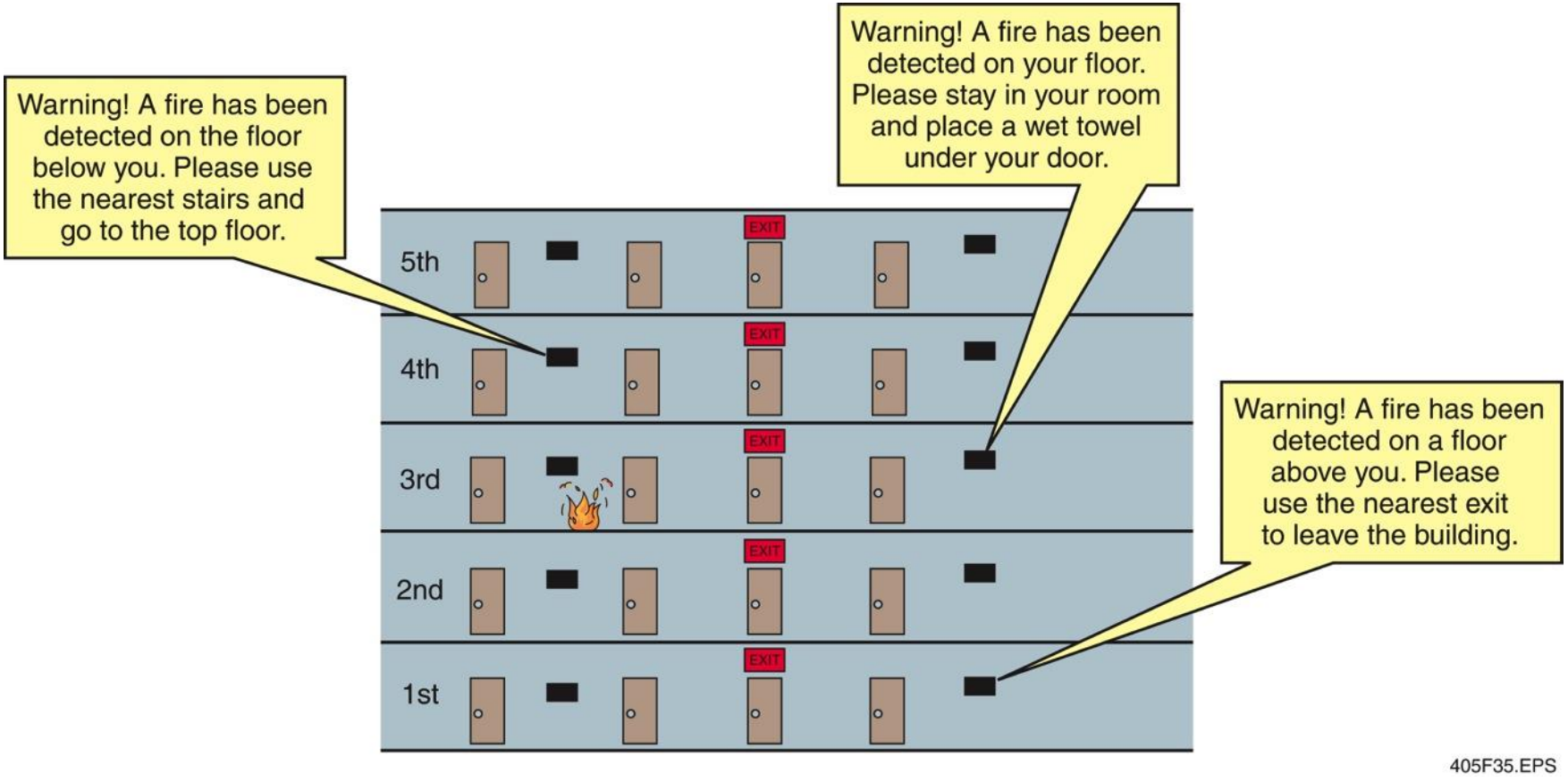
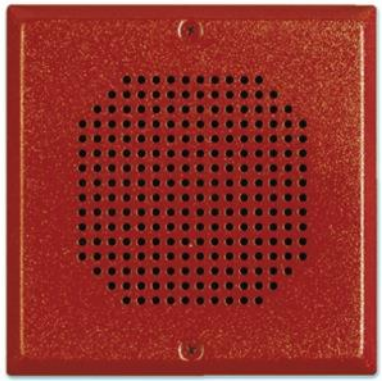
Typical Voice Evacuation Messages



Typical Speakers

- Voice announcements can be made live using a microphone but are typically prerecorded and selected as required by the system.
- Temporal-3 signaling is not used with zoned voice evacuation systems.



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Typical Average Ambient Sound Levels

- Closed doors and equipment noise reduce the effectiveness of an alarm signal and may be insufficient to wake children or hearing-impaired adults.
- Multiple fire sounders provide redundancy and amplify the alarm signal.

Area	Sound Level (dBA)	Area	Sound Level (dBA)
Mechanical rooms	85	Educational occupancies	45
Industrial occupancies	80	Underground structures	40
Busy urban thoroughfares	70	Windowless structures	40
Urban thoroughfares	55	Mercantile occupancies	40
Institutional occupancies	50	Places of assembly	40
Vehicles and vessels	50	Residential occupancies	35
Business occupancies	45	Storage	30

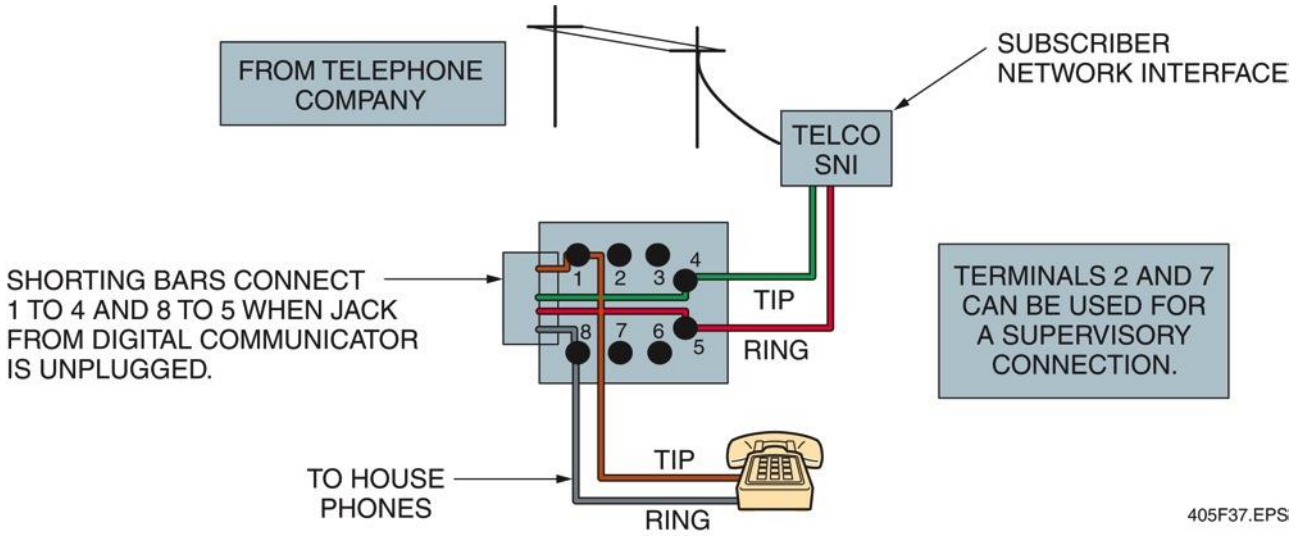
Next Session…

Typical Sound Loss at 1,000Hz

Area	Loss (dBA)
Stud wall	41
Open doorway	4
Typical interior door	11
Typical gasketed door	24

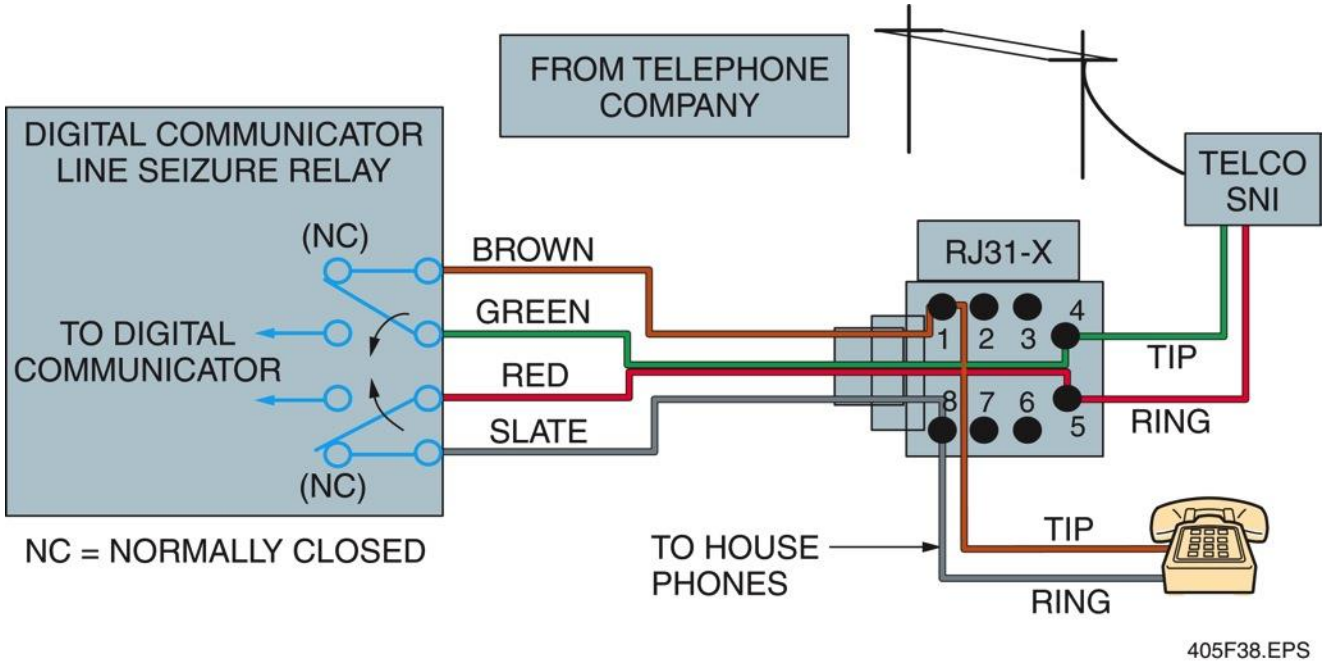
Communications and Monitoring

Communications and Monitoring



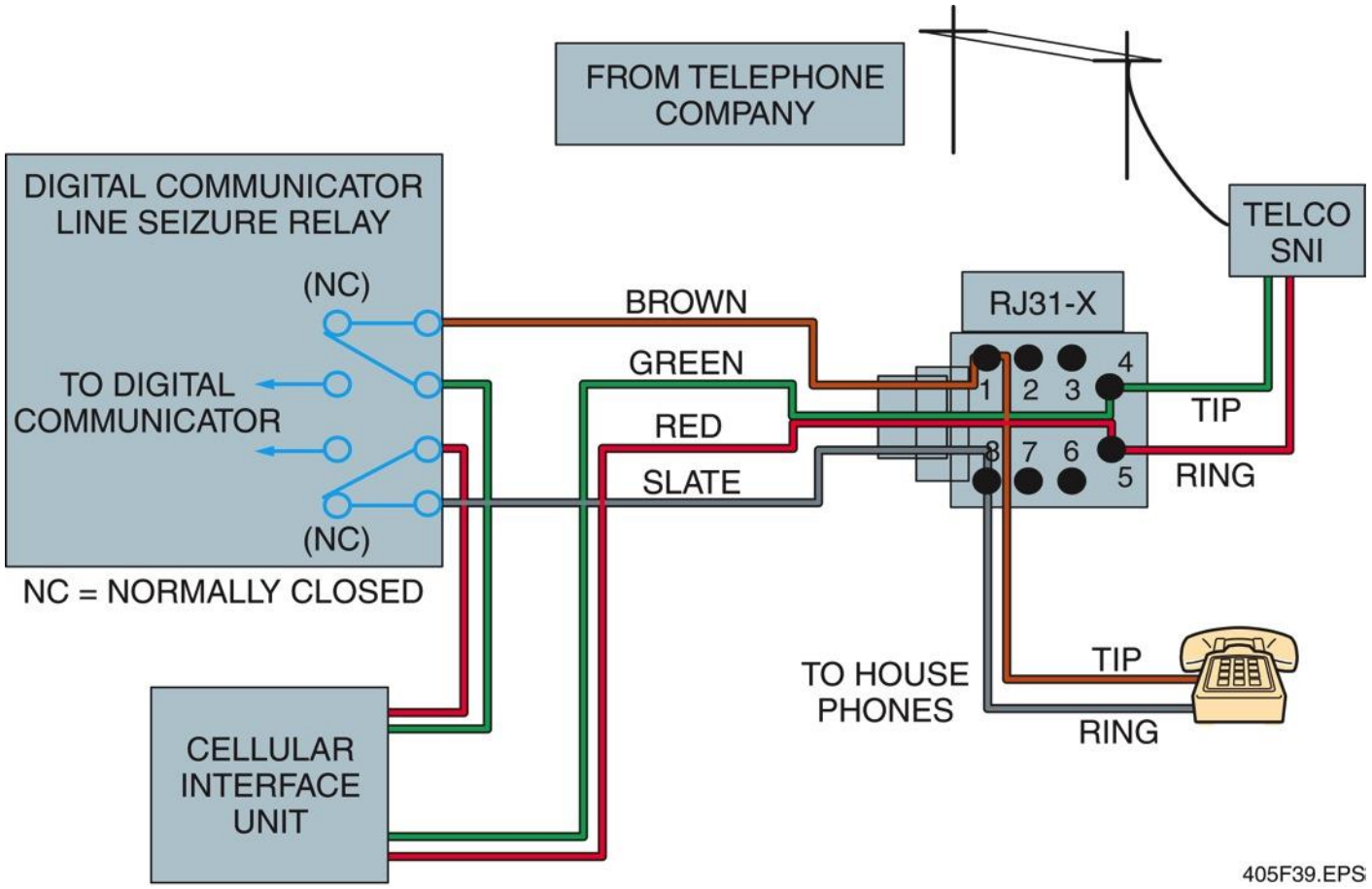
- There are three methods used to monitor an alarm system: central station, proprietary, and certified central station.
- Digital communicators use standard telephone lines with an RJ31-X device or wireless service to send or receive data.

Line Seizure



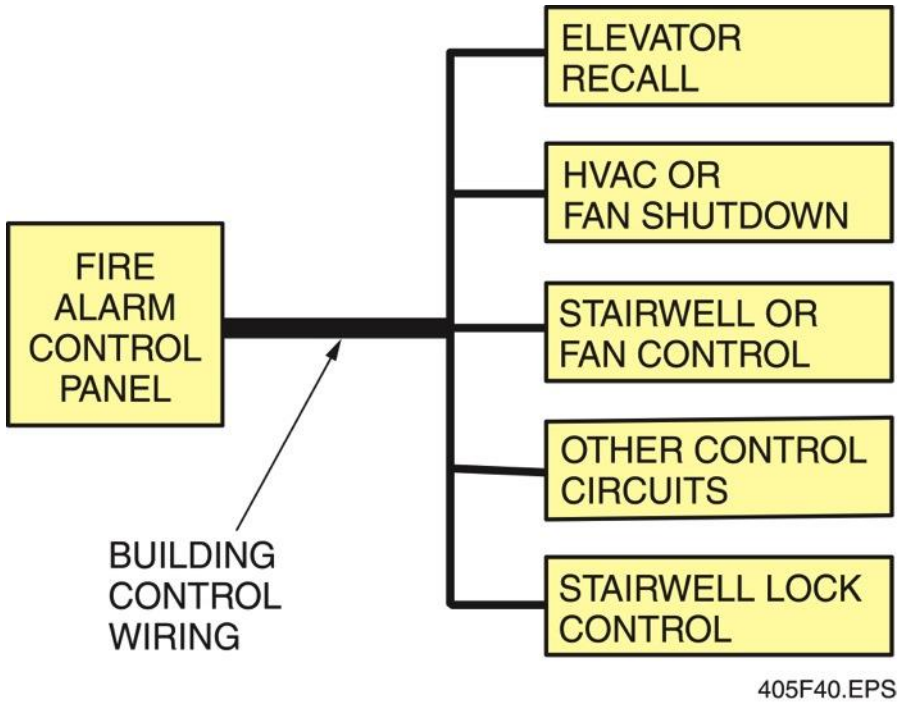
When a telephone line is shared between a standard voice system and an emergency system, line seizure gives the fire alarm system priority in the event of an emergency.

Cellular Backup System



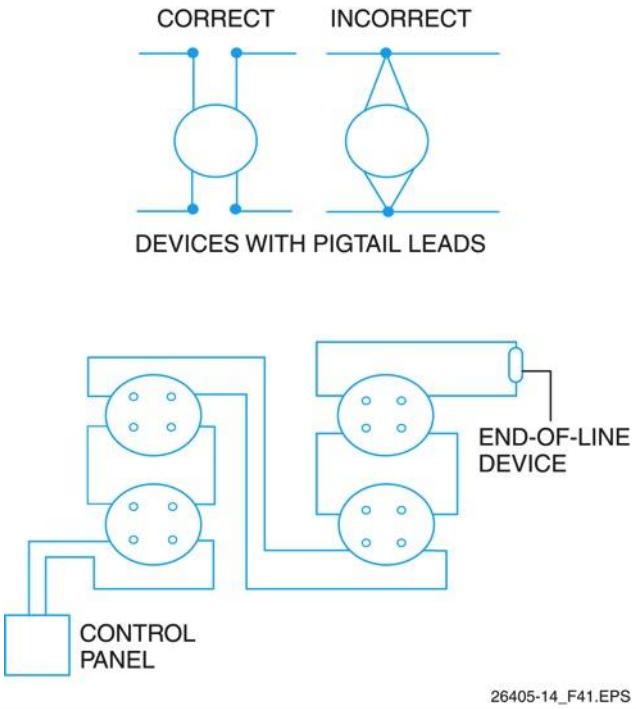
General Installation Guidelines

- Fire alarm systems are covered in ***NEC Article 760***.
- Riser cable is required when running circuits from floor to floor, with appropriate fire sealing as required.
- Power-limited and nonpower-limited circuits must be separated per the *NEC®*.



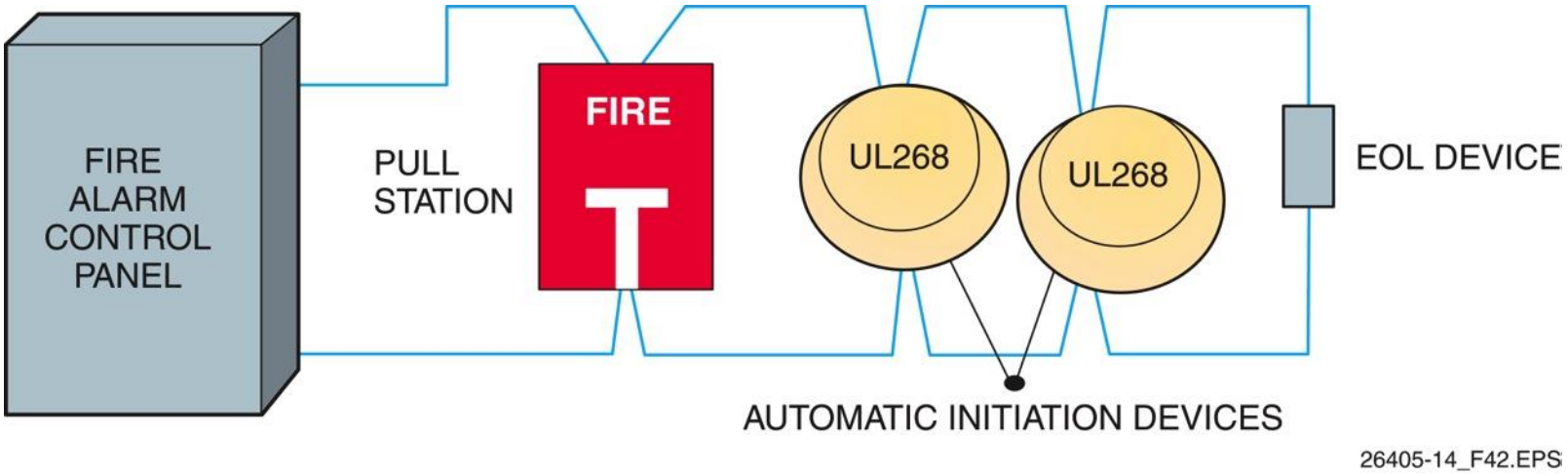
Correct Wiring for Devices with EOL Terminations

The wiring for circuits using end-of-line (EOL) terminations must be done so that removing the device causes a circuit trouble signal.



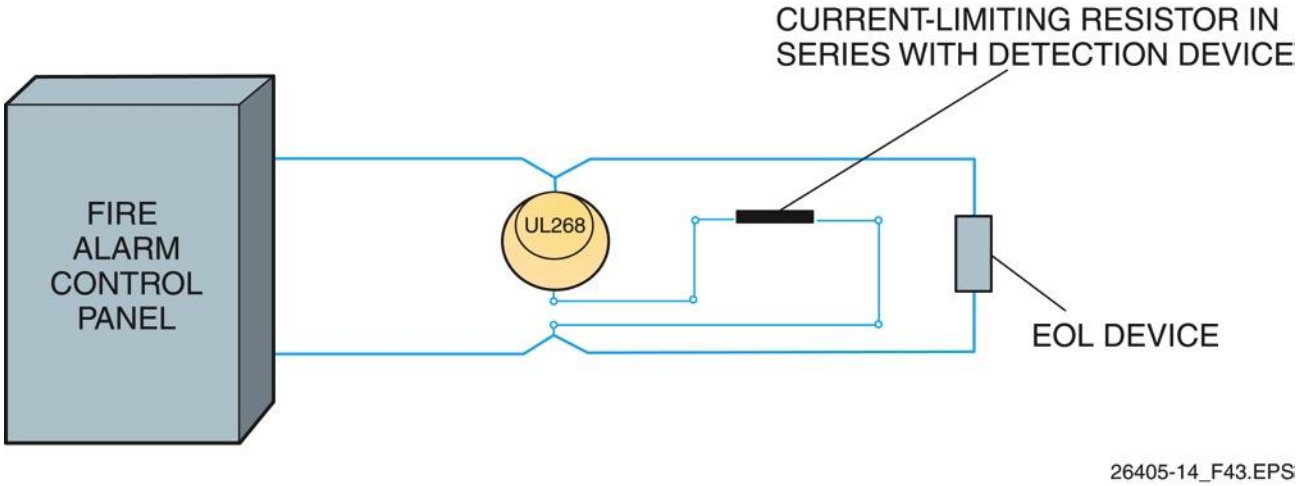
Typical Class B, Style B Initiation Circuit

- There are three styles of Class B and two styles of Class A device circuits listed in *NFPA 72®*.
- A Class B, Style B FACP is required to receive an alarm from any device up to a break with a single open.



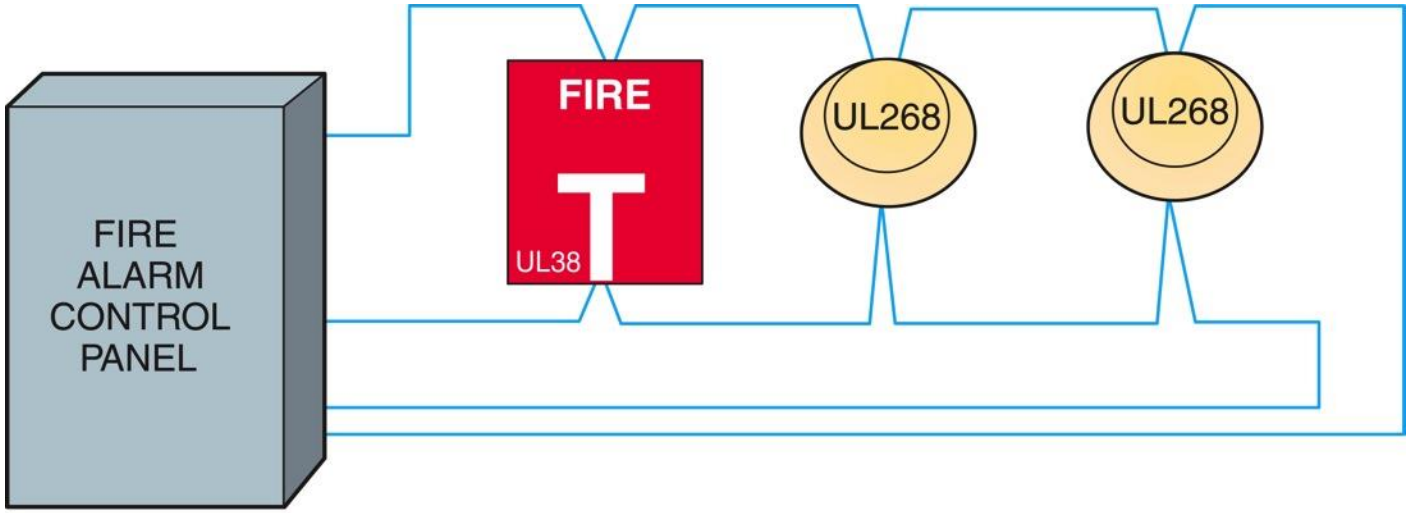
Typical Class B, Style C Initiation Circuit

- Class B, Style C initiation circuits are most common in Europe. An open circuit, ground, or wire-to-wire short will cause a trouble indication.
- Devices on this circuit normally use a resistor in series with the contacts in order for the panel to detect an alarm condition.



Typical Class A, Style D Initiation Circuit

- In Class A, Style D initiation circuits, an open circuit or ground will cause a trouble signal.
- The loop is returned to a special condition circuit, so there is no EOL device.



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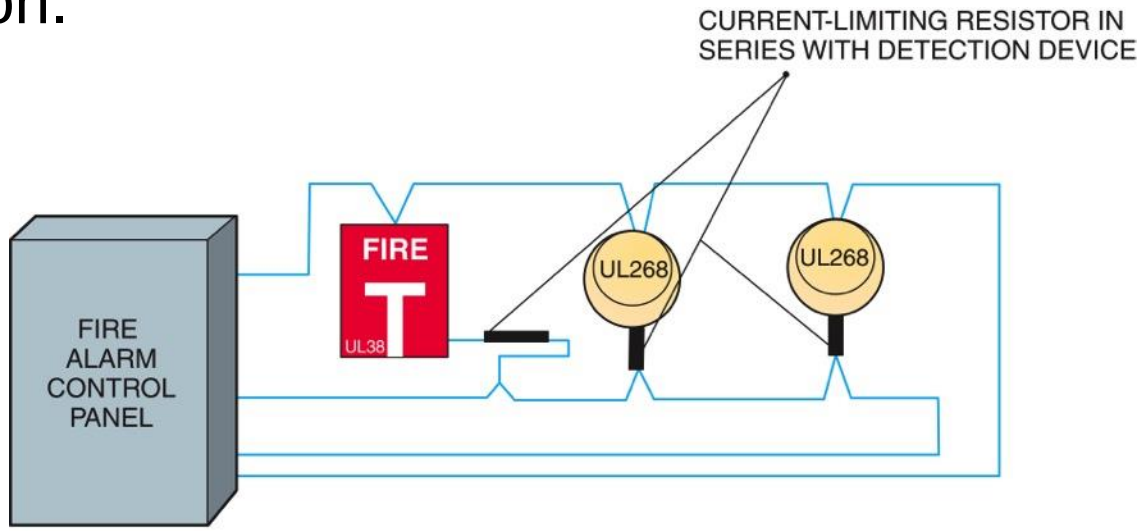
Typical Class A, Style E Initiation Circuit

- A Class A, Style E initiation circuit is an enhanced version of Style D. An open circuit, ground, or wire-to-wire short will cause a trouble indication.
- Devices on this circuit normally use a resistor in series with the contacts in order for the panel to detect an alarm condition.



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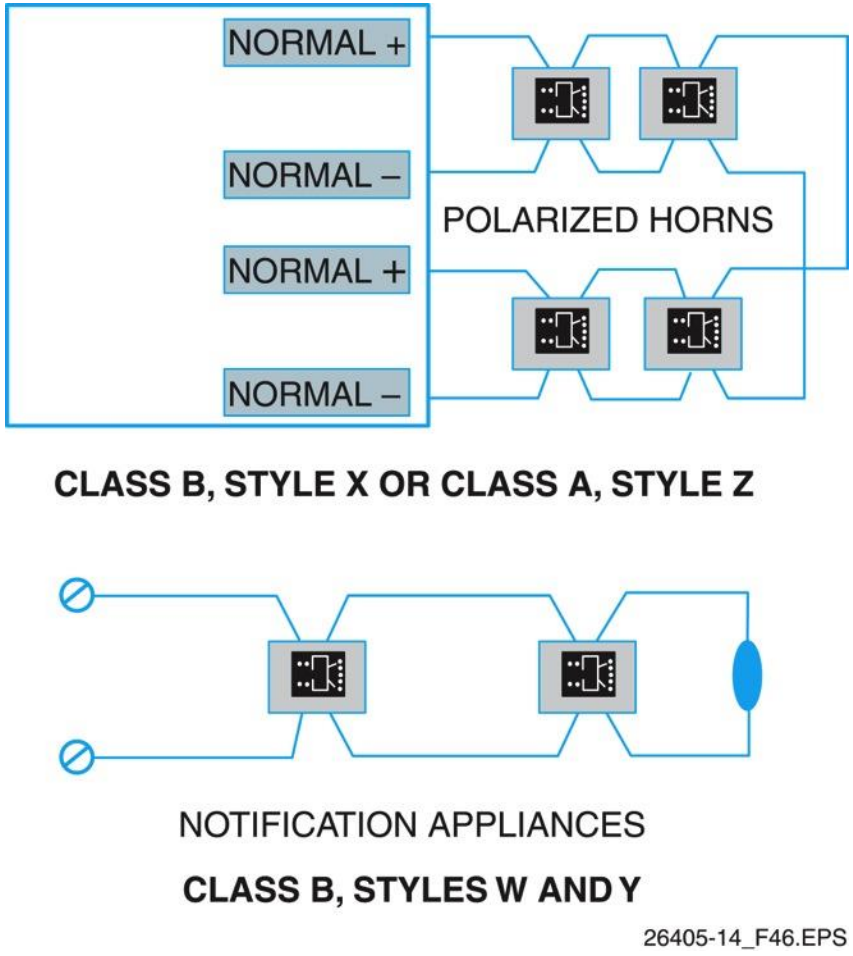
Typical Notification Appliance Circuits



- Class B, Styles W, X, and Y, and Class A, Style Z are used for notification circuits.
- Only Style Z operates all devices with a single open or ground fault.

10.0.0 – 10.20.0

Next Session…

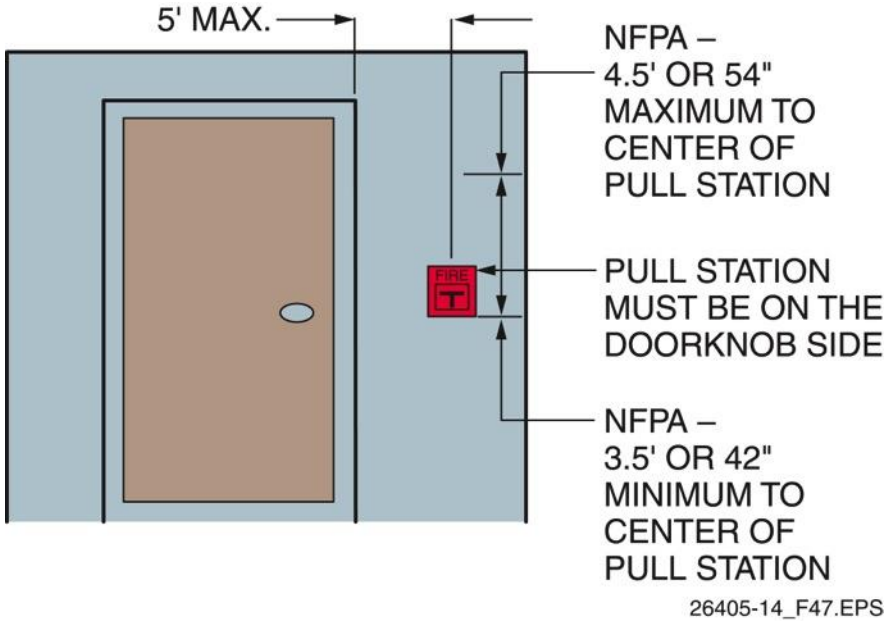
Secondary Power Duration Requirements

NFPA Standard	Maximum Normal Load	Maximum Alarm Load
Central station	24 hours	See local system
Local system	24 hours	5 minutes
Auxiliary systems	60 hours	5 minutes
Remote stations	60 hours	5 minutes
Proprietary	[illegible]	[illegible]
Household system	24 hours	4 minutes
Emergency voice alarm communications systems	[illegible]	[illegible] maximum load 2 hours emergency operation

Total Premises Fire Alarm System Installation Guidelines

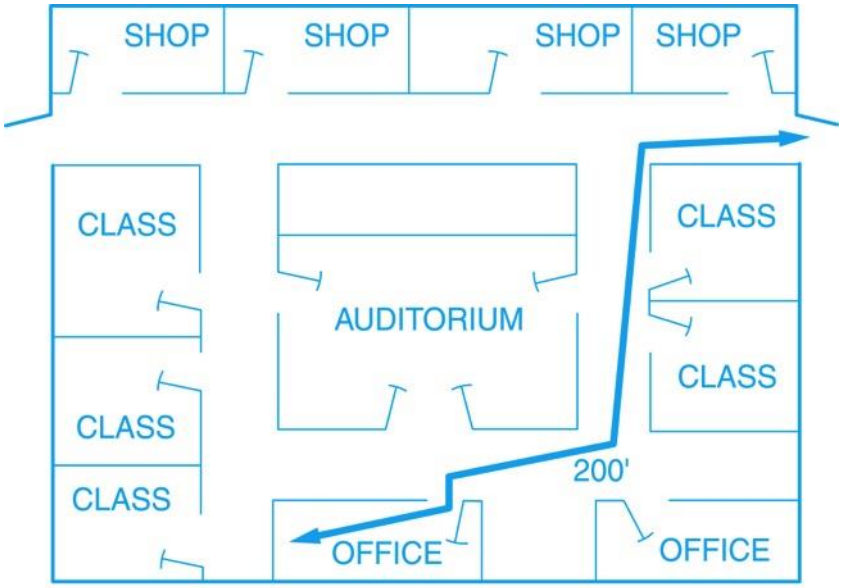
Total Premises Fire Alarm System Installation Guidelines

- In occupancies that require manual initiation, manual pull stations must be installed in the natural path of escape near each required exit from an area.
- The force required to operate a manual pull station must be no more than five foot-pounds.



Maximum Horizontal Pull Station Distance from an Exit

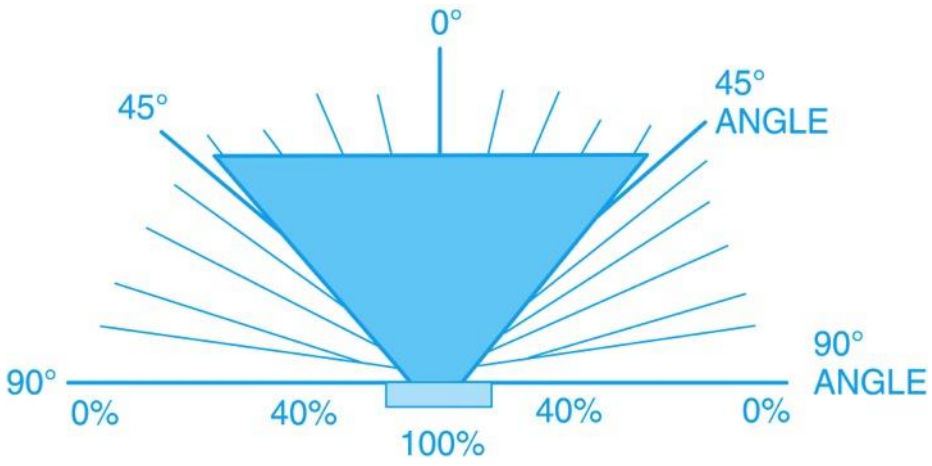
A manual pull station must be within 200' of horizontal travel on the same floor from any part of a building. If the distance is exceeded, additional pull stations must be installed.



26405-14_F48.EPS

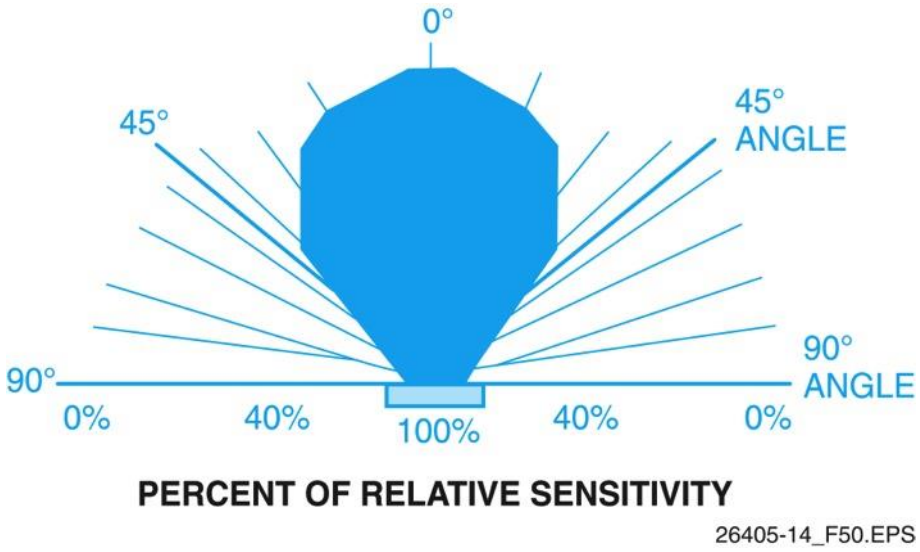
UV Detector Response

- UV detector response time is based on the distance from the fire, angle of view, and fire size. Normally, the field of view is limited to an angle of less than 90 degrees.
- Never aim the unit into direct sunlight or areas where arc welding/cutting may be performed.



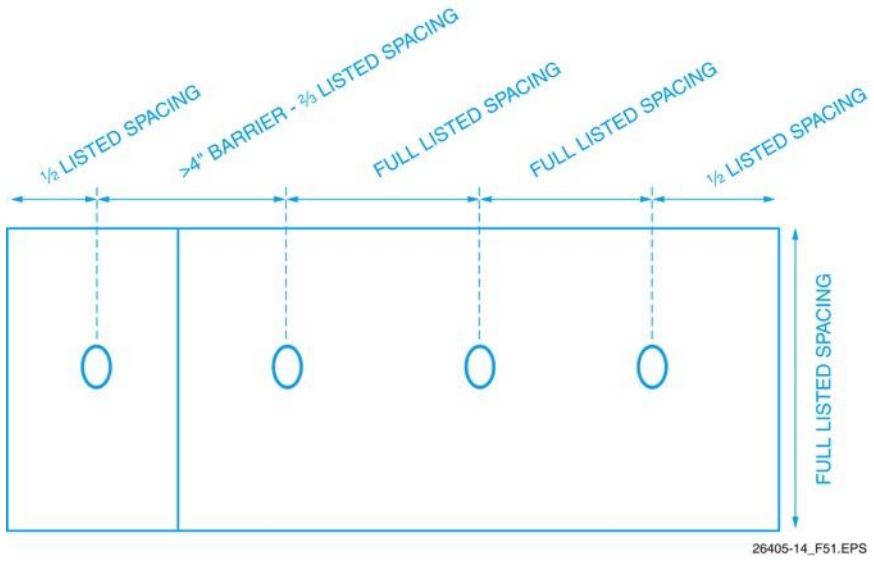
IR Detector Response

- With IR detectors, the response time is based on the angle of view.
- IR detectors cannot be used outdoors and cannot detect alcohol, natural gas, hydrogen, or magnesium fires.
- IR detectors work best in low-light conditions.

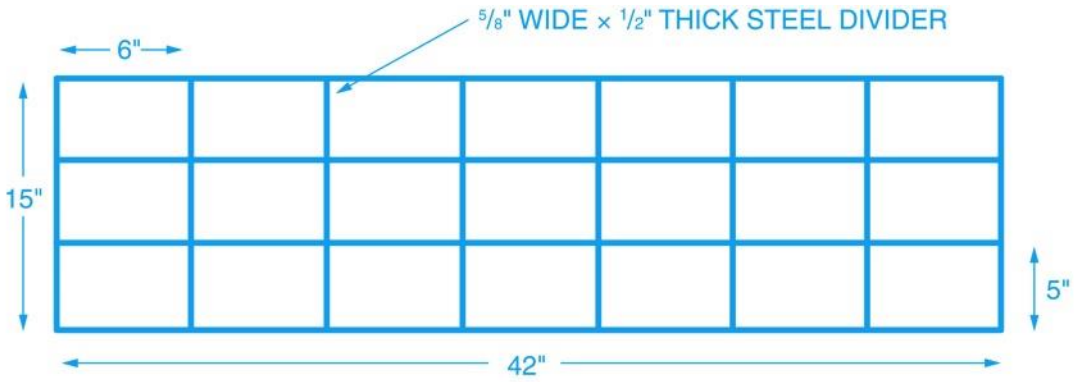


Reduced Spacing Required for a Barrier

- Smoke boundaries include doorways/archways that extend more than 18" down from the ceiling.
- Smoke barriers include doorways/archways that extend more than 4", but less than 18" down from the ceiling, and spacing must be reduced to two-thirds of the listed spacing on either side of the opening.



Detailed Grid Definition



GRID OPENINGS MUST BE AT LEAST 1/4" IN THE LEAST DIMENSION.
OPENINGS ARE 5 3/8" (6" MINUS 5/8") × 4 3/8" (5" MINUS 5/8").
REQUIREMENT MET.

THE THICKNESS OF THE MATERIAL DOES NOT EXCEED THE LEAST DIMENSION.
OPENINGS ARE 5 3/8" (6" MINUS 5/8") × 4 3/8" (5" MINUS 5/8"). THICKNESS IS 1/2".
REQUIREMENT MET.

THE OPENINGS CONSTITUTE AT LEAST 70% OF THE AREA OF THE PERFORATED MATERIAL.
OPENINGS ARE 5 3/8" (6" MINUS 5/8") × 4 3/8" (5" MINUS 5/8")
5 3/8" × 4 3/8" = 23 1/2 sq. in.

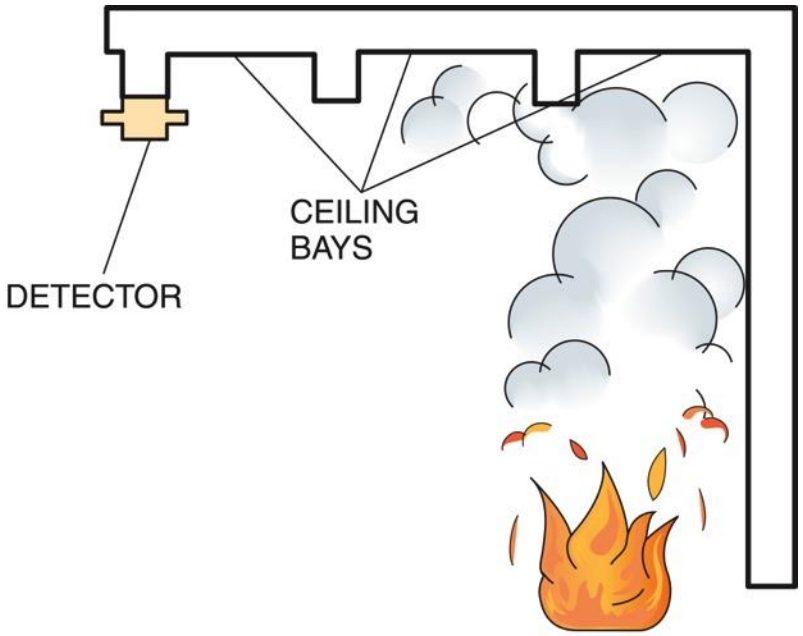
21 OPENINGS × 23 1/2 sq. in. = TOTAL OPENING = 493 1/2 sq. in.
15" × 42" = 630 sq. in. 630 sq. in. × 0.70 = 441 sq. in.

REQUIREMENT MET.

26405-14_F52.EPS

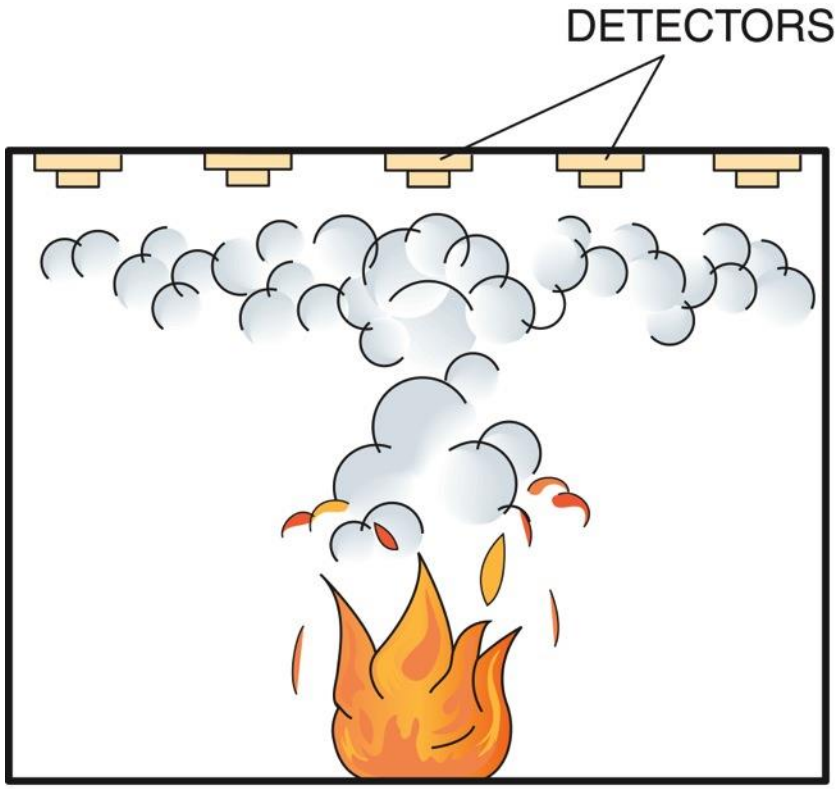
Smoke Spread Across a Beamed or Joist Ceiling

In the case of a beamed or joist ceiling, the smoke will fill the closest bay before moving on to other bays.



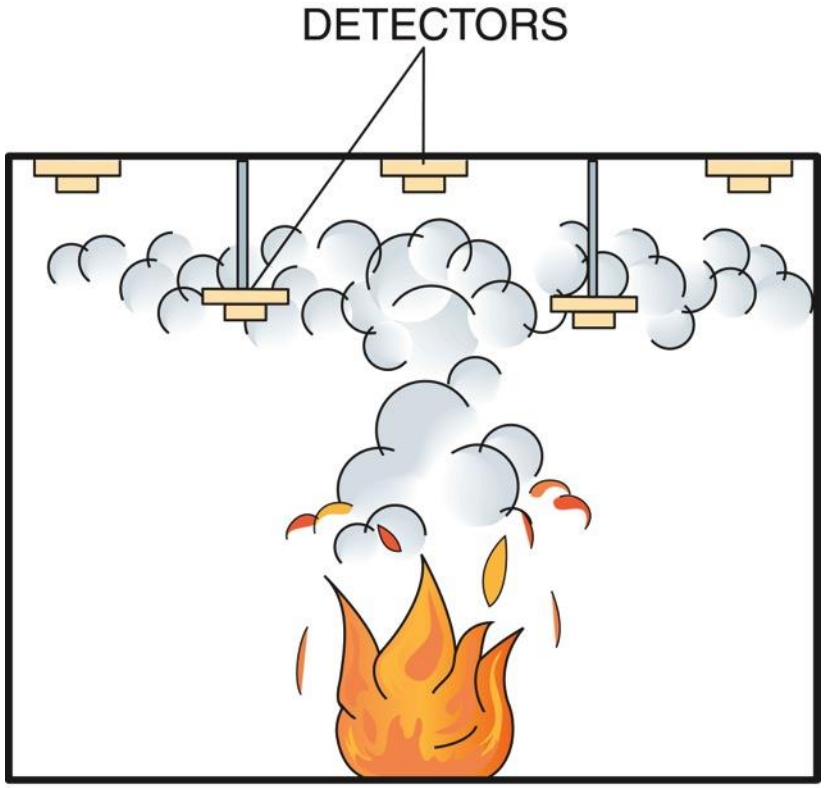
Smoke Stratification

- Under certain conditions, when smoke rises, it tends to cool and stratify. This can result in a layer of toxic gases at lower levels.
- Stratification can be caused by thermal air blocks caused by uninsulated roofs, HVAC systems that produce a hot layer of ceiling air, and extremely high ambient temperatures.



Smoke Stratification Countermeasure

Detectors can be alternated at lower levels to compensate for stratification.



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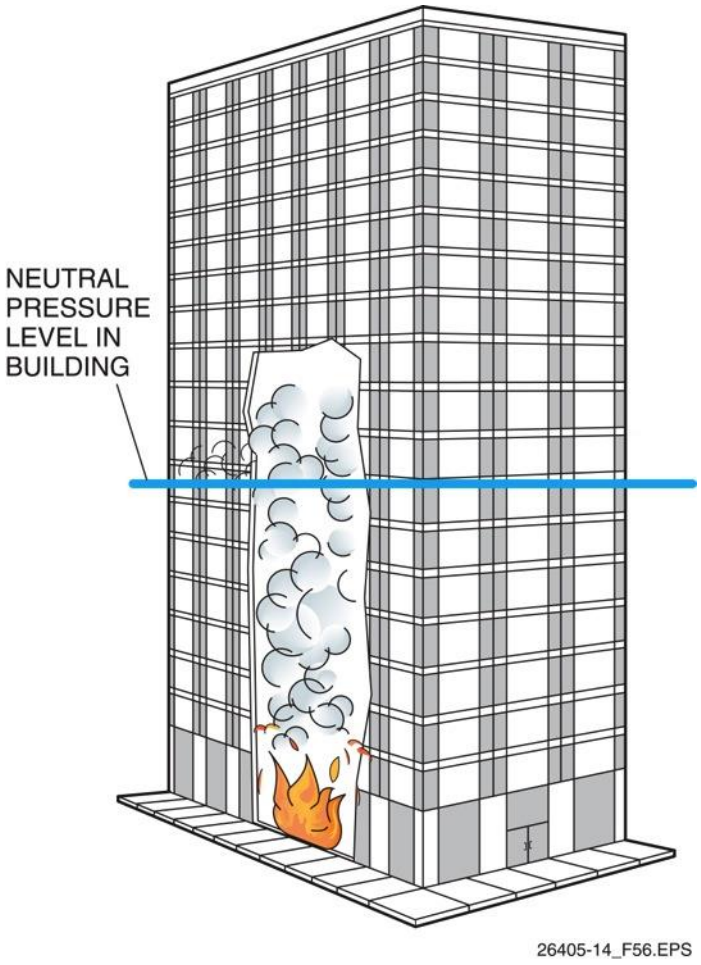
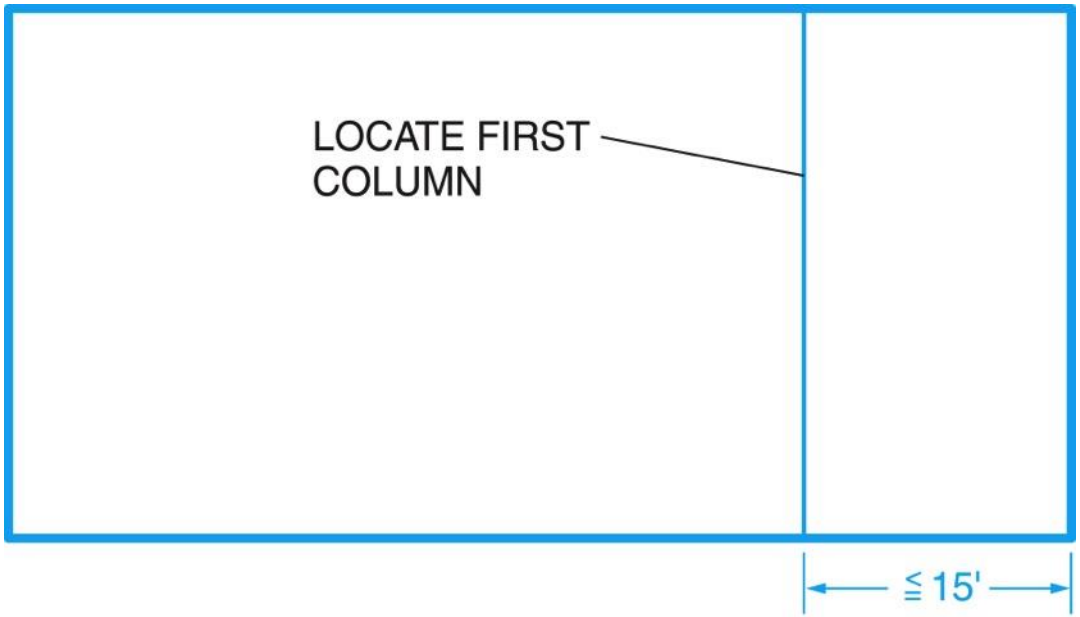
Stack Effect in a High-Rise Building



- Stratification can also occur in high-rise buildings due to the stack effect.
- The factors that contribute to stack effect include building height, air tightness, leakage between floors, interior/exterior temperature differential, vertical openings, and wind force/direction.

Locating the First Column

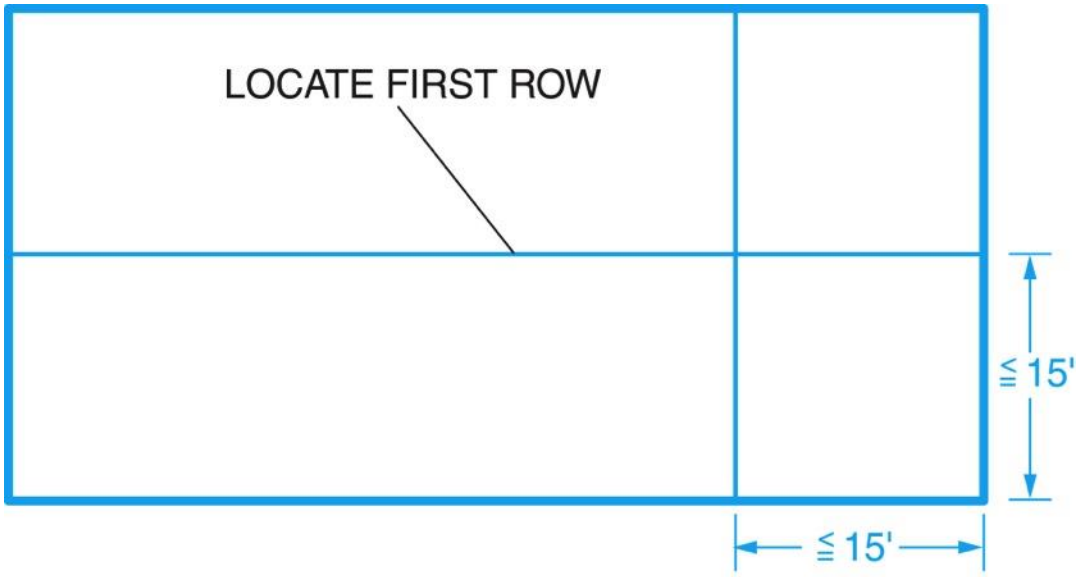
When installing spot detectors on smooth, flat ceilings, the first column is located parallel to the end wall and at no more than half of the listed spacing (in this case, half of 30' or 15').



26405-14_F57.EPS

Locating the First Row

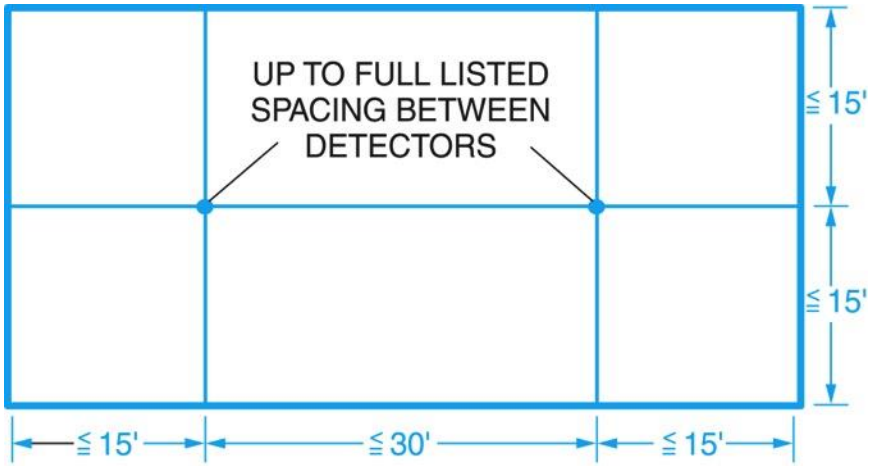
The first row is located parallel to the sidewall and at no more than half of the listed spacing (in this case, half of 30' or 15').



26405-14_F58.EPS

First and Second Detector Locations

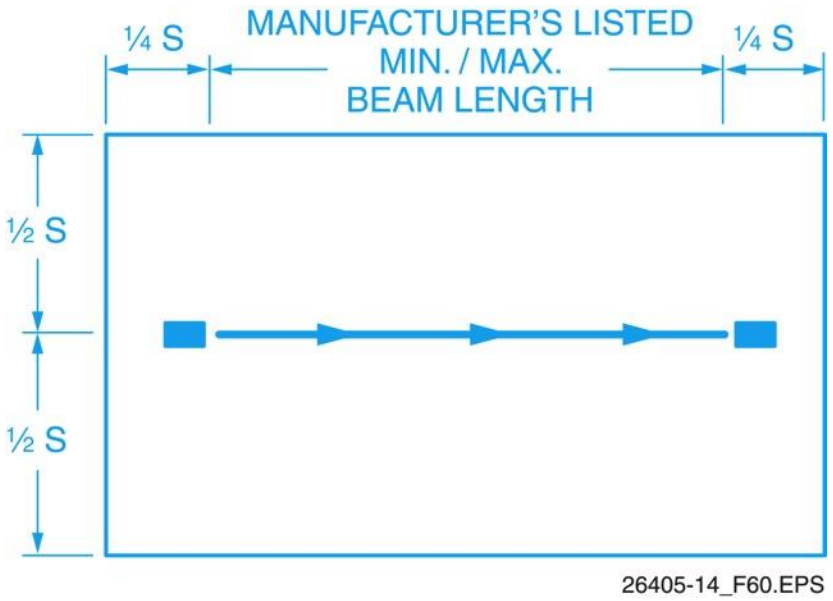
- The second column is located parallel to the opposite end wall and at no more than half of the listed spacing.
- The first detector is located at the intersection of the first row and first column. The second detector is located at the intersection of the first row and second column, as long as it does not exceed the minimum detector spacing.



26405-14_F59.EPS

Maximum Straight-Line Single-Beam Smoke Detector Coverage (Ceiling View)

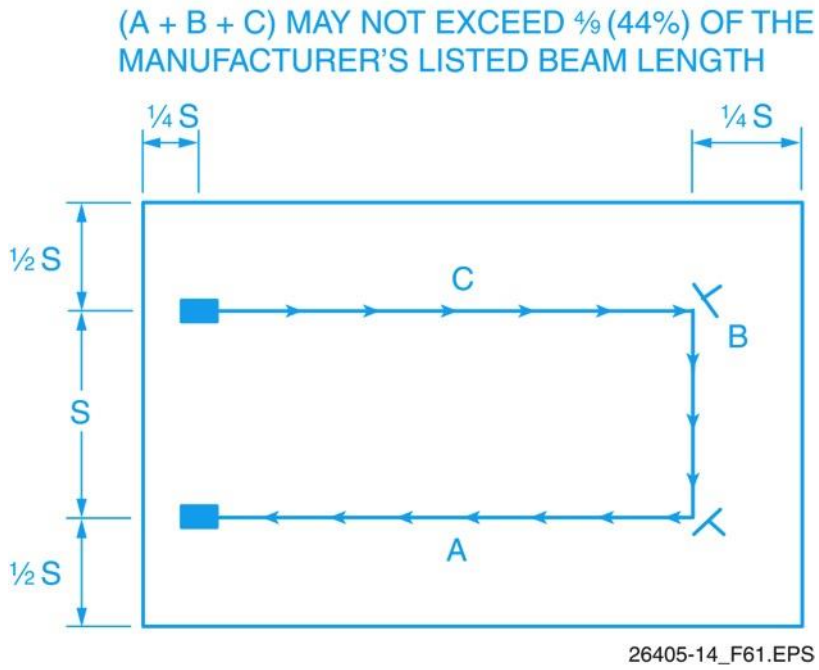
- Photoelectric beam smoke detector manufacturers typically list the minimum/maximum length of coverage (beam length) for each detector, and may also supply dimensions for the spacing width (S).
- Where the width is not listed, the 60' guideline from *NFPA 72®* must be used.



26405-14_F60.EPS

Coverage for a Two-Mirror Beam Detector Installation

- Mirrors may be used to redirect the path of a beam director if allowed by the detector manufacturer and the mirrors are listed for this use.
- This setup reduces the manufacturer's listed beam length to 66% of the listed beam length for one mirror and 44% for two mirrors.



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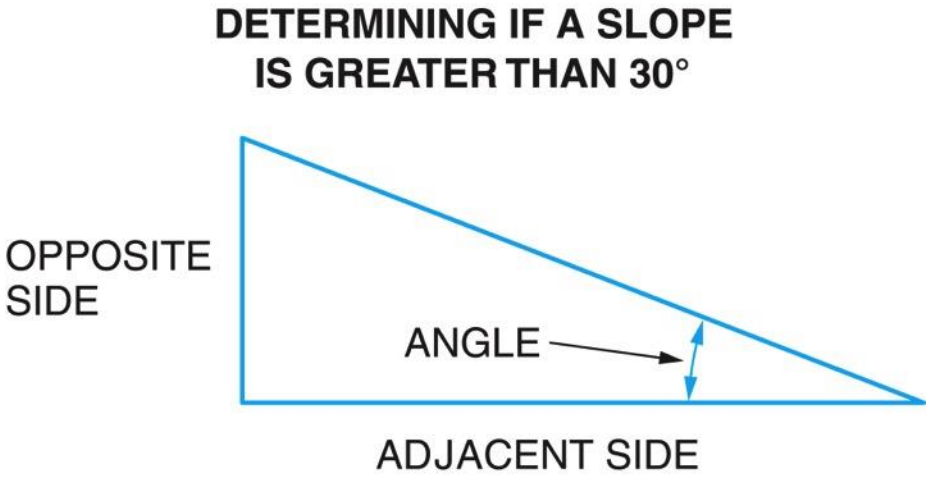
Determining Degree of Slope



If the opposite side divided by the adjacent side is > 0.5774, the angle is > 30°.

The tangent of the smallest angle of a right triangle equals the opposite side divided by the adjacent side.

The sum of all the angles of a triangle equals 180°.

The tangent of a 30° angle is 0.5774.

26405-14_F62.EPS

Visual Notification Devices Required for Corridors Not Exceeding 20'

Corridor Length (in ft.)	Minimum Number of 15cd Appliances Required
0–30	1
31–130	2
131–230	3
231–330	4
331–430	5
431–530	6

Room Spacing for Wall-Mounted Visual Notification Appliances

Maximum Room Size (in ft.)	Minimum Required Light Output in Candelas (cd)		
	One Light per Room	Two Lights per Room*	Four Lights per Room**
20 × 20	15	Not allowable	Not allowable
30 × 30	30	15	Not allowable
40 × 40	60	30	Not allowable
50 × 50	95	60	Not allowable
60 × 60	135	95	Not allowable
70 × 70	185	95	Not allowable
80 × 80	240	135	60
90 × 90	305	185	95
0 × 100	375	240	95
110 × 110	455	240	135
120 × 120	540	305	135
130 × 130	635	375	185

* Locate on opposite walls
** One light per wall

Room Spacing for Ceiling-Mounted Visual Notification Appliances

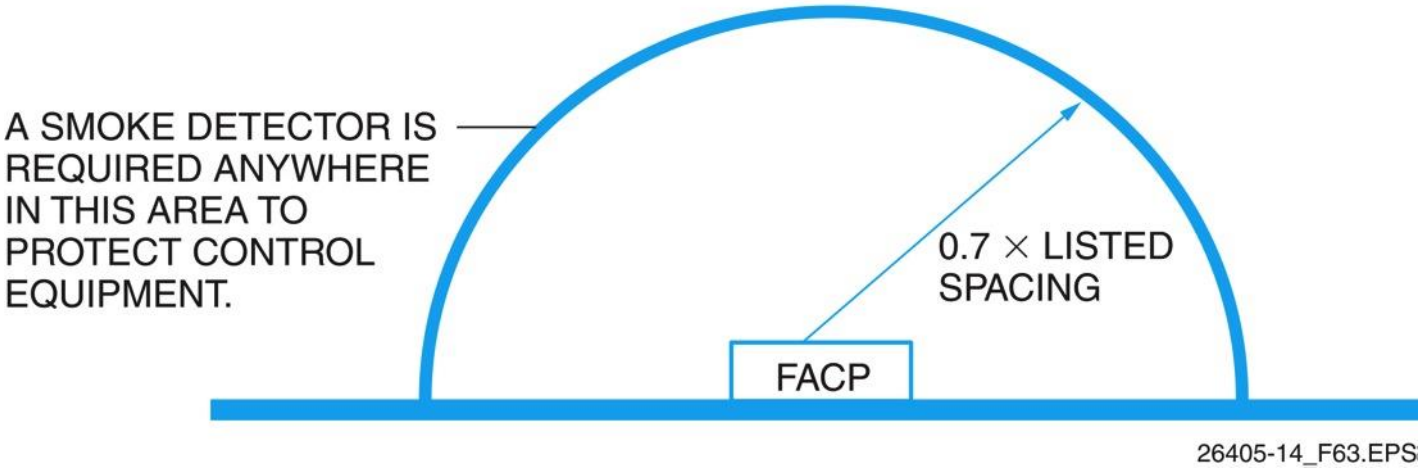
Maximum Room Size (in ft.)	Maximum Ceiling Height (in ft.)*	Minimum Required Light Output for One Light (cd)**
20 × 20	10	15
30 × 30	10	30
40 × 40	10	60
50 × 50	10	95
20 × 20	20	30
30 × 30	20	45
40 × 40	20	80
50 × 50	20	95
20 × 20	30	55
30 × 30	30	75
40 × 40	30	115
50 × 50	30	150

* Where ceiling heights exceed 30', visible signaling appliances must be suspended at or below 30' or wall mounted in accordance with *NFPA 72®*.
** This table is based on locating the visible signaling appliance at the center of the room. Where it is not located at the center of the room, the effective intensity (cd) must be determined by doubling the distance from the appliance to the farthest wall to obtain the maximum room size.

Protection of an FACP

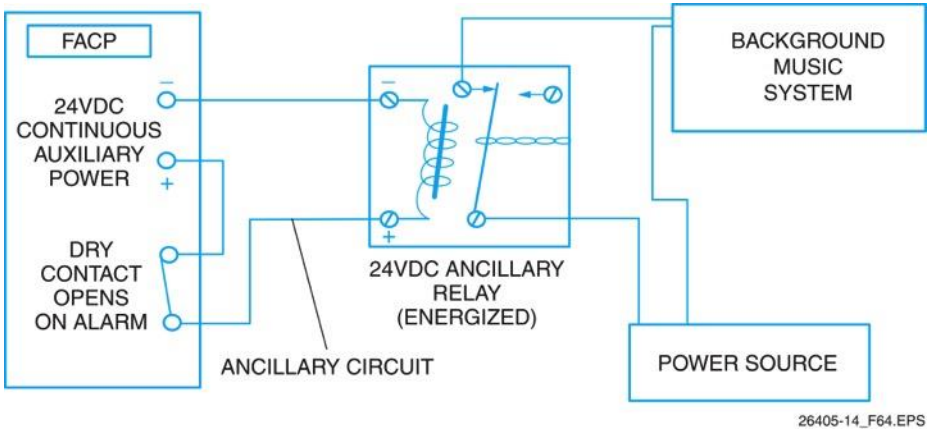
Fire alarm control equipment must also be protected by a smoke/heat detector unless it is in a continuously occupied area.

A smoke detector protecting control equipment must meet *NFPA 72* spacing and placement standards, but the entire space (room) containing the FACP need not be protected.



Fire Alarm-Related Systems and Installation Guidelines

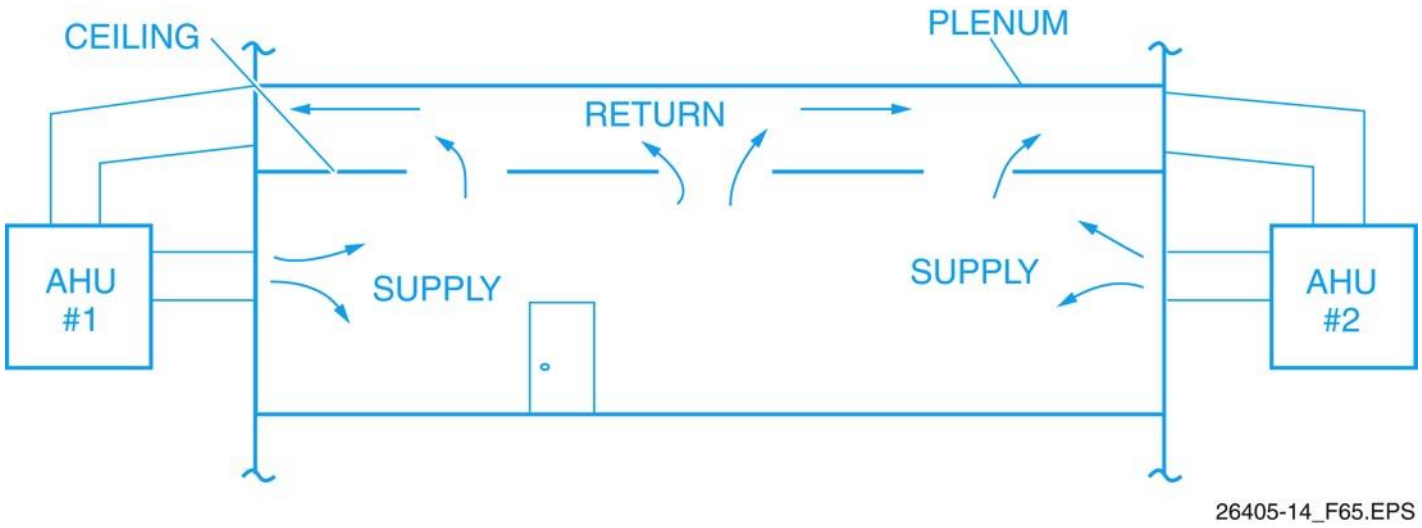
- Auxiliary functions in the event of a fire include emergency lighting, elevator recall and shaft pressurization, smoke management systems, HVAC system shutoff, and door unlocking/control.
- Fire alarm systems typically override the building's background music system so that the evacuation signal can be heard.



Conversions

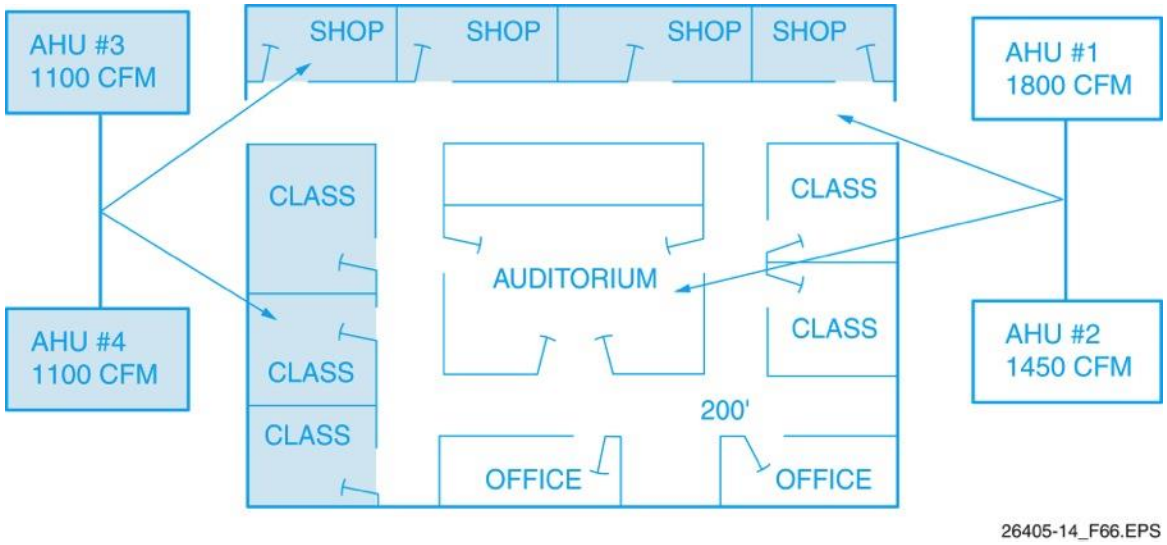
Capacity Rating	CFM
1 ton	400
12,000 Btus	400
5 tons	2,000
60,000 Btus	2,000
37.5 tons	15,000
450,000 Btus	15,000

Non-Ducted Multiple AHU System



When more than one air-handling unit (AHU) is used to supply air to a common space, the total capacity of all units must be used in determining the size of the HVAC system.

Example in which all AHUs Require Detectors on the Supply Side



- AHUs #3 and #4 serve the same common space and must be added (1,100 cfm + 1,100 cfm = 2,200 cfm).
- Because 2,200 cfm > 2,000 cfm, duct smoke detectors are required for both units. The same is true for AHUs #1 and #2.

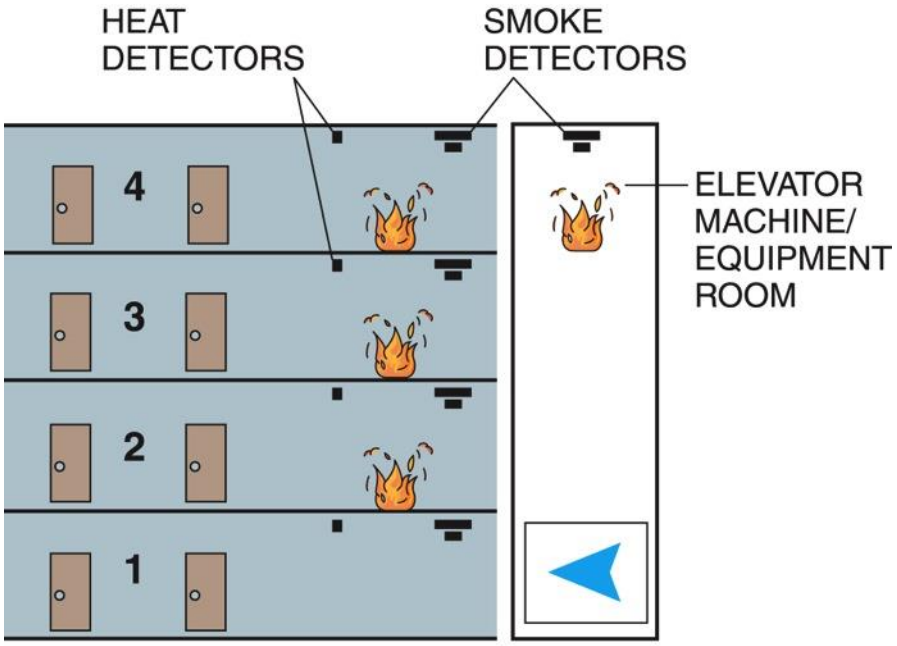
Typical Remote Duct Indicator

- AHUs often come with factory-installed duct detectors.
- Where remote duct indicators are installed in a building with a fire alarm system, duct detectors must be connected to that system and may require battery backup.

26405-14_F67.EPS

Phase 1 Recall

- Elevator recall reroutes an elevator to a non-fire floor, opens the doors, and then puts the elevator out of service until it has been reset.
- Phase 1 recall recalls the elevator to the floor with the highest probability of safe evacuation.

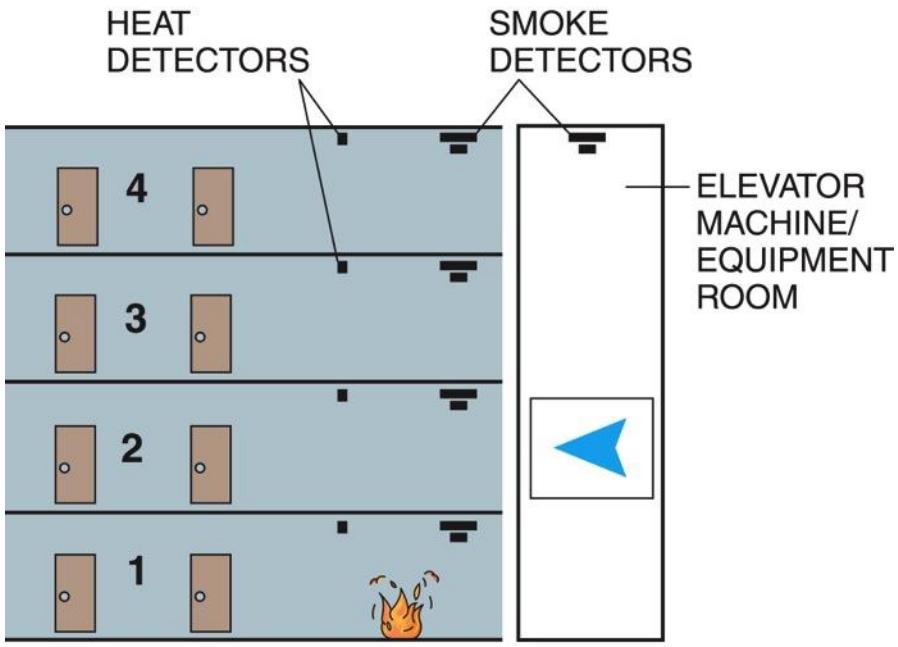


PHASE 1 RECALL:
Activation of any of these detectors sends all cars to the designated level.

26405-14_F68.EPS

Phase 2 Recall

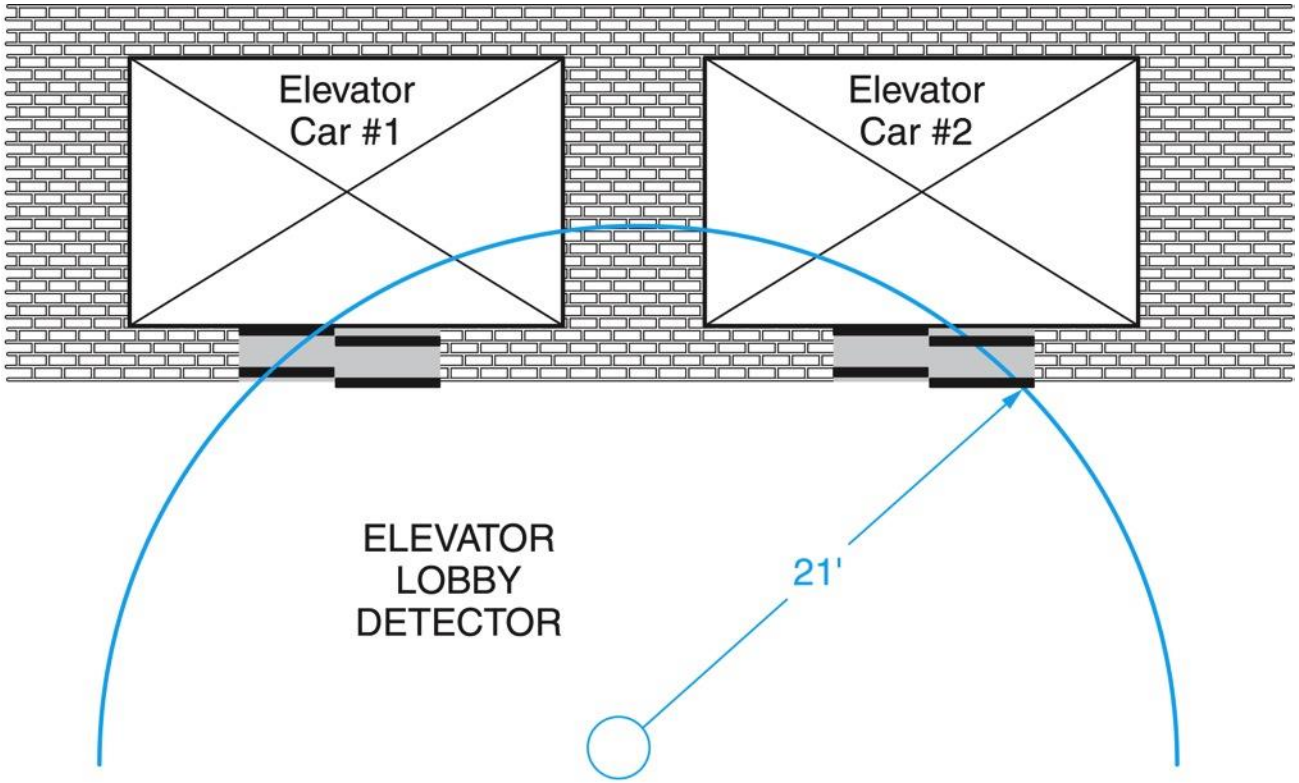
- Phase 2 recall recalls the elevator to the floor with the next highest probability of safe evacuation.
- Phase 2 recall is normally activated by the smoke detector in the lobby where the elevator would normally stop during a Phase 1 recall.



PHASE 2 RECALL:
Activation of the designated level detector sends all cars to the alternate floor.

26405-14_F69.EPS

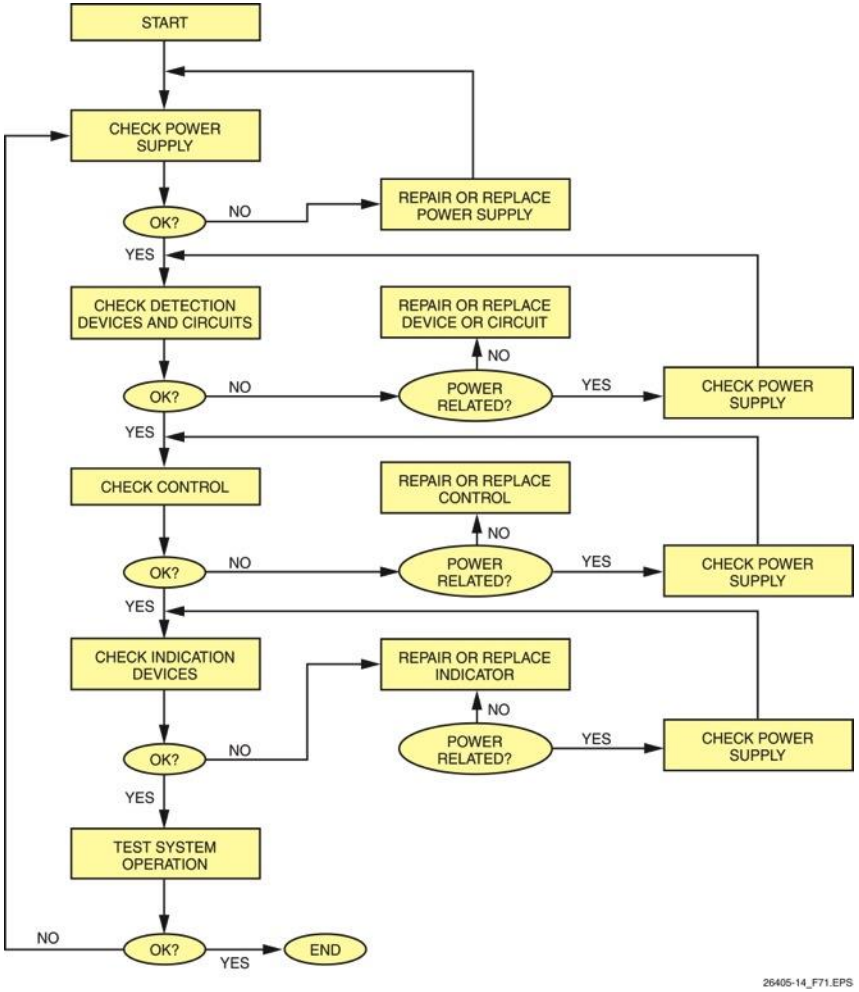
Elevator Lobby Detector



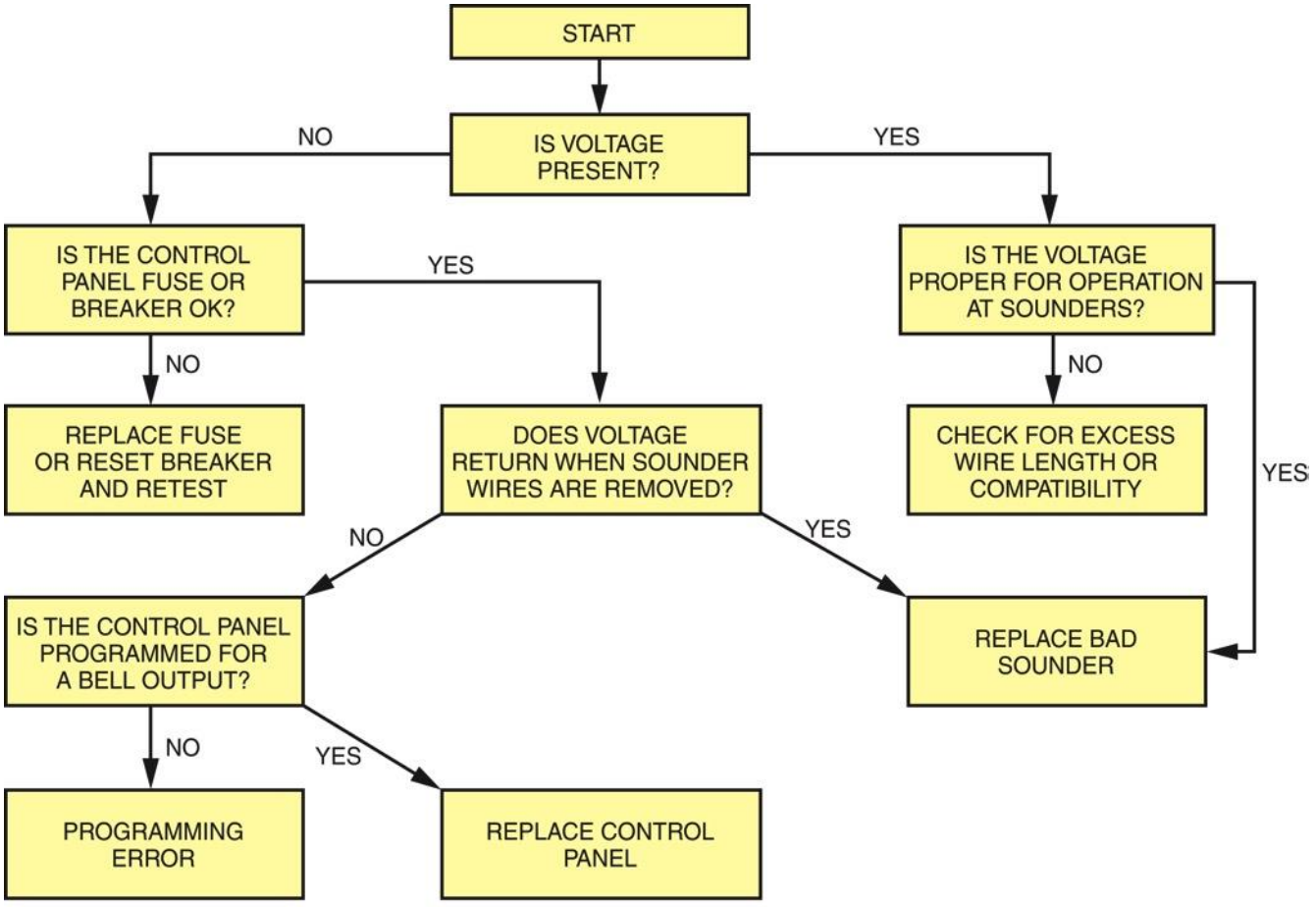
Assumes a 30' listed detector on a smooth and flat ceiling.
Target protection should be the extreme edges of the elevator door opening.

26405-14_F70.EPS

Troubleshooting



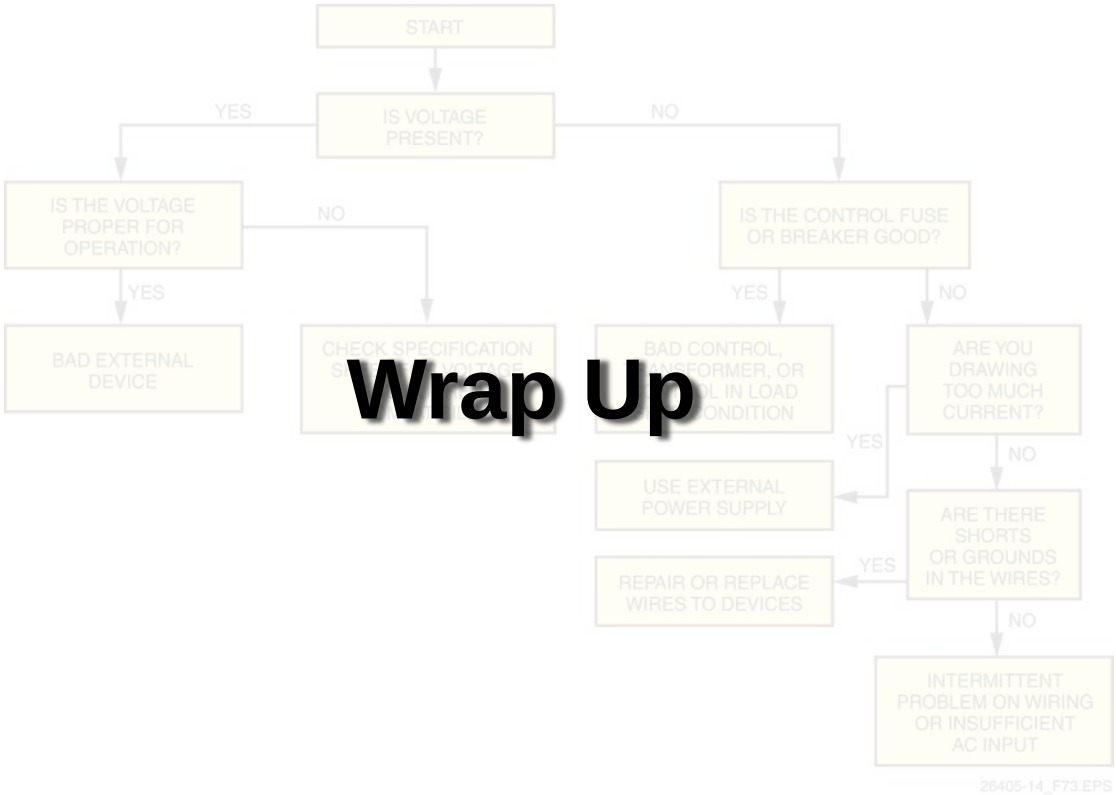
Alarm Output Troubleshooting



13.0.0 – 13.2.0

Next Session...

Auxiliary Power Troubleshooting



Wrap Up

Performance Task

This session will conclude with trainees connecting selected fire alarm systems.

Wrap Up

3-2-1

3 – Write 3 important things learned during class

2 – Write 2 questions you have about the material

1 – Write 1 thought you had about the material

Next Session…

MODULE EXAM

Review the complete module to prepare for the module exam. Complete the Module Review as a study aid.